DEER MOVEMENTS AND HABITAT USE DURING WINTER

WORKING PLAN

INTEGRATED WILDLIFE INTENSIVE FORESTRY RESEARCH

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Province of British Columbia

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Working Plan

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1 PROBLEM REFERENCE

A problem analysis titled "Intensive Forestry Effects on Vancouver Island Deer and Elk Habitats"[1] was prepared during February 1982 for the Integrated Wildlife - Intensive Forestry Research (IWIFR) program, a co-operative research venture between the B.C. Forest Service and B.C. Ministry of Environment. The research topic it identified as having the highest priority was how forestry practices could be used to create suitable black-tailed deer (Odocoileus hemionus columbianus) and Roosevelt elk (Cervus elaphus roosevelti) winter habitat in young-growth stands. This working plan provides details of the research to be conducted on deer winter habitat during the winter of 1984/85.

1.1 Patterns of Winter Range Use

The concept of winter range for wild ungulates is familiar to wildlife ecologists throughout the temperate and colder regions of the world, but its meaning varies greatly among species and locations. At the simplest level, the winter range of one animal or a group of animals is merely the area in which the winter months are passed. Phrased this way, the term connotes nothing about the features of the habitat on the winter range. However, through local usage in relation to a single species the term "winter range" in most northern regions has come to mean a special set of vegetation and topographic conditions, or a specific location, that traditionally shelters large numbers of animals.

Among wildlife and forest managers, the common conception of winter range for Vancouver Island blacktail deer is a moderately to steeply sloped area of southerly aspect at low elevation (<800 m), supporting an old-growth stand of timber with a high component of Douglas-fir (Pseudotsuga menziesii), abundant rooted forage (especially Gaultheria shallon and Vaccinium spp.), and arboreal forage lichens (mainly Alectoria and Bryoria spp.). Thi

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[1] J.B. Nyberg. 1982. Problem analysis - intensive forestry effects on Vancouver Island deer and elk habitats (EP 934). Unpubl. rep., B.C. For. Serv., Burnaby, B.C. 95 p.

definition of winter range has developed from research in the mountain valleys of central Vancouver Island (Jones 1975; Stevenson 1978; Harestad 1979; Rochelle 1980) and from extensive surveys of other areas by the Ministry of Environment.

Even though old-growth winter ranges as described above are known to be preferred deer habitats during periods of deep uncrusted snow, use of such stands, and the need for them as critical deer habitats, varies greatly among areas, among winters, and even within winters. On Vancouver Island, in the lowlands, coastal plains, and low-elevation mountains that border the ocean in all areas except the north-central coast, deep and persistent snowpacks are infrequent (although not unknown), and old-growth stands are not regarded as critical habitats in most years (Hebert 1979). At elevations above 800 m throughout the Island, snowpacks are so deep in most winters that deer use is minimal. However, winter-to-winter variations in weather can modify the typical temporal and spatial pattern of deer concentration. Long snowy periods on the coast may drive deer into restricted areas; and warm winters in the inland mountains may leave the animals free to roam through all but subalpine and alpine habitats. This lack of concentration by deer on "critical" ranges during mild winters was discussed by Harestad (1979) as a potential adaptive advantage for them. During any one winter, it is also common for deer to move on and off a given winter range numerous times, as the weather alternates between cold, snowy conditions and warmer spells during which much of the snowpack melts. The reasons are not clear for the rapid dispersal of deer from winter ranges when snow conditions allow, but among the strong possibilities is that old-growth winter ranges are not the most preferred foraging habitats in the absence of snow.

1.2 Key Features of Winter Ranges

Given the variability in deer use of winter ranges, plus the unexplored influences of predation, thermal cover requirements, food competition, and social behaviour, our studies of winter range could encompass many facets of deer ecology. Over most of Vancouver Island, though, there appear to be two

key features that distinguish critical winter ranges from other nearby habitats. One is the presence of rooted and arboreal forage in adequate amounts; the other is a secondary effect of topographic position and tree cover, which results in more favourable snowpack conditions, and hence increased mobility and reduced energy expenditure for deer. Increased mobility leads to better access to forage and thermal cover, and better opportunities for escape from predators.

1.3 Research Goals

Our research goals are: 1) to determine what food and snowpack features are present in old-growth winter ranges as compared to other habitat types; 2) to identify the relative importance of snow and forage in affecting winter habitat use; and 3) to investigate the possibilities for creating deer winter ranges with young-stand management. Although old-growth types are known to provide important deer winter ranges in many areas, valuable economic and recreational benefits would result if managers could provide winter ranges in younger stands. Not only would this reduce or eliminate the need to retain old-growth stands for winter range, but it could also restore the productive capacities for deer in areas where no old growth exists due to past fires or logging.

2 LITERATURE REVIEW

The subject of ungulate winter range has been extensively researched throughout the cold regions of North America and Eurasia. Most studies have addressed either the habitat characteristics of heavily used ranges or the energetic/physiological relationships between animals and weather or food. Descriptive studies of winter ranges usually assume that concentrations of animals occur in the most favourable habitats, and seek to define how these preferred habitats differ from others available nearby. Studies of the functional relationships between animals, weather, and food are usually designed with an energetic model of environmental stress in mind, and are often not specific to particular habitat types.

Because of the predictive power that could be realized by wildlife and forest managers understanding the functional processes linking climate, environment, and animals, the exploration of functional relationships among these factors should yield the greatest long-term benefits. For reasons of funding, timing, and staffing, research on functional relationships is best suited to the laboratory or controlled field experiments. In support of our work the University of British Columbia (UBC) is currently conducting research on thermal stresses on deer[2]. Important steps remain to be taken in empirically evaluating the key features of winter ranges, including contrasting old-growth stands with young-growth stands, and therefore we have chosen a largely descriptive approach for this stage of the program. An important adjunct to this type of study, and one we are currently planning, is the large-scale experimental treatment of land areas to test our understanding in an active or prescriptive way. We have also planned a more detailed investigation of the relationships between forest stands and snow interception (Section 3.4). Although much has been published on the subject of ungulate winter range throughout the world, most areas studied have been very different from the cool, moist forests of coastal British Columbia. Therefore, the following literature review is brief and specifically concerned with studies in forest and climate conditions similar to Vancouver Island.

2.1 Deer Winter Ranges

Fifteen years of research on blacktail deer in north-central Vancouver Island have revealed that some low-elevation, old-growth forest stands provide better food and snow conditions than other nearby habitat types with which these old-growth winter ranges were compared. Jones (1975) found snow to be approximately twice as deep in recently logged areas as in old-growth stands at the same elevation, and found a significant negative correlation between canopy closure and snow depth in the forest. He also noted that deer

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[2] K.L. Parker. 1984. Thermal regulation in black-tailed deer with particular emphasis on the effects of rain: research proposal. Unpubl. rep., Faculty of For., Univ. of B.C., Vancouver, B.C. 12 p.

avoided logged areas when snow was deep and soft, preferring to remain in the timber; but found extensive use of logged habitats when the snowpack developed a hard crust that supported the weight of the deer. He concluded that forests having crown closure levels of 65% or greater are suitable winter range where snowfalls are heavy.

Jones found that, within old-growth stands, deer use was heavier where understories were dominated by shrubs rather than by conifers. He also suspected that arboreal lichens were important in determining where deer wintered, and that heavy lichen loads may have attracted deer to higher elevations in spite of the heavier snowpack found there as compared to lower slope positions.

Stevenson (1978) studied lichen litterfall and use by deer during a mild winter. Deer were usually found where arboreal forage lichens (especially Alectoria) were moderately or highly abundant. Sampling indicated that deer use of Alectoria litterfall ranged from 13.5 to 92.5 kg/ha for the 180-day winter period, and that these levels of use represented consumption of 37-53% of the available Alectoria litterfall.

Harestad (1979) conducted a radiotelemetry study of deer movements in the Nimpkish valley, the same area studied by Jones (1975) and Stevenson (1978). He found that deer habitat selection varied with weather conditions, and confirmed the importance of old-growth timber during periods of heavy snow. He emphasized the importance of old growth in allowing deer to maximize net energy acquisition; that is, energy intake from forage minus energy expended for movement. This approach stresses the combined effects of snow and forage production as the key influences on deer, rather than the absolute amount of snow or food. Thus, abundant forage was of no use if it was completely covered in snow, and snow-free areas with no food were less valuable than those with some available forage. Harestad found that certain low-elevation old-growth types offered both more forage and less snow than adjacent, logged habitats. He hypothesized that a snow depth of 37 cm represented a threshold of locomotive restriction for Columbian black-tailed deer. He also observed that deer did not remain in "critical" winter ranges after conditions moderated, and that some old-growth types which are preferred during mild

winters could be very important to long-term deer survival, reducing pressure on critical ranges except during the worst weather conditions.

After an intensive study of deer forage resources in the Nimpkish Valley, Rochelle (1980) reaffirmed the importance of old-growth timber stands as winter habitat, because of their arboreal lichens and modified snowpacks.

Other recent studies in south-east Alaska have also found old growth to be valuable winter habitat for deer. Bloom (1978) noted that stands with canopy closure levels of 80% or better were most heavily used because of their reduced snow depths, but also noted that stands with mixtures of dense and open canopies were used heavily at the edges of the openings, due to the greater shrub abundance in the open. Merriam (1968) found snow to be twice as deep in openings as it was under old-growth timber canopies, and recorded little deer use in habitats with snowpack depths of 37 cm or more. Ongoing studies by the Alaska Department of Fish and Game (Schoen et al. 1981a) have confirmed that Sitka black-tailed deer prefer densely canopied old growth during winter, due to the reduced snow depths.

These studies have clearly demonstrated the superior winter range value of old-growth stands as compared to logged areas supporting young trees in the shrub/seedling or early pole/sapling stages of succession, i.e., less than 20 years since logging. However, few studies have compared old growth with young seral or mature seral stands (20 - 100 years since logging). Wegge (1977) sampled deer use and snow depths in old growth and adjacent 23-year-old young growth, and found deer use higher and snowpack depth lower in the old growth. The young-growth stand had a "stocking" (presumably crown closure) level of only 45%, much lower than the 60-80% closure in the old-growth stand. Other studies (Wallmo and Schoen 1980) have shown use to be lower in densely stocked, even-aged young growth than in old growth. However, recent studies at the UBC Research Forest in Haney indicate that 80- to 100-year-old stands intercept more snow than old-growth stands do (R.S. McNay, pers. comm.).

Many people have suggested that it may be possible, using existing

forestry practices, to grow a relatively young stand (< 100 years) that is capable of wintering substantial numbers of deer, even in a deep-snow winter. For example, Rochelle (1980, p. 273) stated that "As second-growth stands develop, specific forest management prescriptions, including the use of thinnings and fertilization, can be employed to manipulate stand structure. Use of these silvicultural techniques should allow the manager to produce the desired canopy structure for effective interception of snow as well as to permit the development of forage plants in the understory." Rochelle added the caution that stands less than 100 years old are unlikely to support large amounts of forage lichens.

If good winter ranges are distinguished by the amounts of forage they produce and the shallower snowpacks they create, as well as the topographic situations in which they occur, there is good reason to suppose that younger stands on the right sites could winter substantial numbers of deer. Many unmanaged stands of 60-100 years of age contain trees nearly as large as the trees in some dry-site old-growth winter ranges, and canopy closure usually exceeds the 60% figure recommended by Jones (1975) once a stand is 20 years or older. After an extensive review of North American literature reporting canopy influences on snowpack, Harestad and Bunnell (1981, p. 856) concluded that "... canopy cover integrates age and species characteristics, and provides a single parameter which can be used to predict SWE (snow-water equivalent) in coniferous forests." Because snow-water equivalent is calculated from both snowpack depth and density, and does not relate directly to the snowpack's effect in hindering deer movement, Harestad and Bunnell's conclusion does not necessarily imply that increasing canopy closure leads to better snowpacks for deer in all stands, particularly very young ones. It does offer some promise for older young-growth stands.

Literature reviewed elsewhere[3] has shown that the potential exists for enhancing forage production on some sites through thinning in young stands.

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[3] J.B. Nyberg. 1982. Working plan - intensive forestry effects on deer and elk forage. Unpubl. rep., B.C. For. Serv., Burnaby, B.C. 47 p.

However, this does not apply to arboreal lichens, as pointed out by Rochelle (1980). A further complication arises when one considers the opposing effects that opening the forest canopy has on forage production and snow interception. A mix of densely canopied and open patches will probably be required within any young-growth stand if it is to function as winter range.

The literature cited thus far has emphasized either snowpack depth or forage abundance as the key parameter, and only Harestad (1979) discussed in detail the combined effect of these two variables. The discussion section in the other reports reveals that most of the authors recognized the interaction of the two parameters as being more important than either one taken alone. For example, Jones (1975) pointed out that snowpack depth was irrelevant when the snow became crusted, because then deer could travel easily through openings in search of food, despite the deeper snow found there. Sinking depth is a more appropriate measure of snow hindrance than snowpack depth; and sinking depth is a function of many parameters of both snow and deer, including snowpack depth, surface hardness, density at various depths, deer foot-loading, gait, slope, and others (Parker 1983).

Harestad (1979) discussed the differences in forage availability that result when snow buries rooted forage plants. With deep snowpacks, abundant and preferred shrubs may become almost completely unavailable to deer, and this emphasizes that it is forage availability during the winter that must be assessed, rather than forage abundance during the growing season.

In considering how a young-growth stand might be treated to make it a good deer winter range, one is immediately confronted with the question of how to reduce sinking depth while simultaneously ensuring the presence of available rooted forage. Snow interception is positively related to canopy closure, forage abundance is negatively related. This is probably why uniform, even-aged mature stands do not make good deer ranges (Schoen et al. 1981b). If they are open-canopied with abundant forage, snow will be too deep; and if they are very dense, there will be little snow but also little food. Old-growth stands, with their typically patchy and multi-storied canopies, provide an intermixture of shallower snow and reasonably abundant

forage that is not found in most younger stands. Data on typical patterns of snowpack and forage availability within old-growth winter ranges in coastal British Columbia are negligible.

3 PROJECT COMPONENTS

Our plans for the 1984/85 winter season cover several different aspects of the winter range problem. Research will be conducted by a group composed of members of the IWIFR deer and habitat teams. The component studies will be described separately, with scheduling and priorities for the different activities covered in Section 3.5.

3.1 Snow, Forage, and Deer Use Differences Among Stands

As discussed above, one of the prerequisites to prescribing forestry treatments for winter range creation is a set of criteria describing the desired habitat features of winter ranges. Previous descriptions of old-growth winter ranges have not been sufficiently detailed for this purpose, nor have relationships between stand characteristics and snow interception or redistribution been analyzed. This portion of the project is designed to gather both types of data in an area of high deer density.

3.1.1 Objectives

The general objectives of this sub-project are: 1) to describe and contrast snowpack characteristics, forage availability, and deer use in a high value old-growth winter range, a poor quality old-growth range, and several younger stand types; and 2) to begin an investigation of the effects of forest stand parameters on snow interception. More specifically, we will:

1. test for differences in mean snowpack depths, snow density to 55-cm depth, forage availability, and the frequency distribution of snowpack depths among four habitat types in each of two study areas (Dunsmuir Creek and Jump Creek, both in the Nanaimo River drainage - see Figure 1). These tests are to be conducted at least three times during the winter, within two days after storms that deposit at

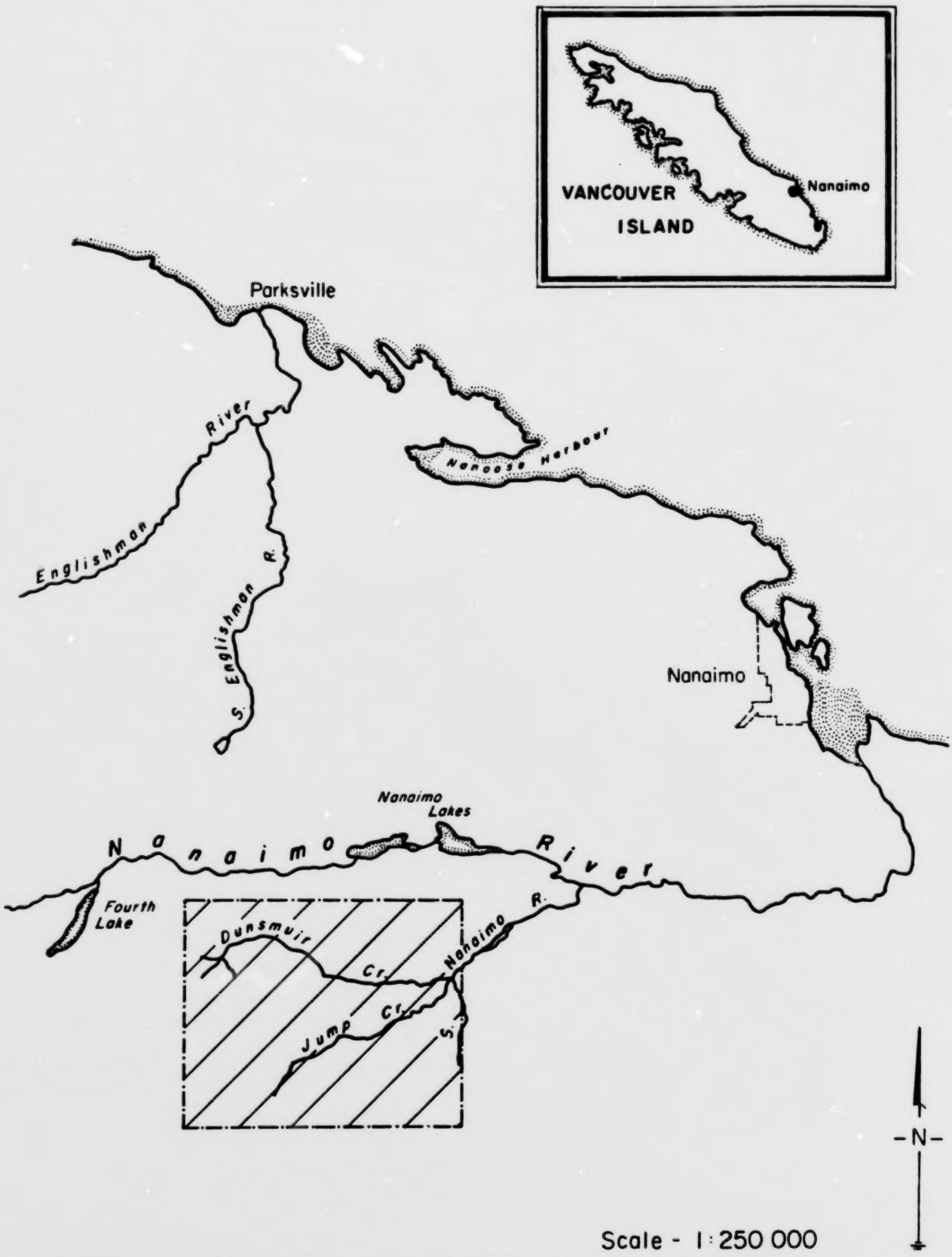


FIGURE 1 Location of Jump Creek-Dunsmuir Creek study area, Nanaimo River watershed.

least 2.5 cm of snow in all habitats at low elevation, i.e. enough snow to show deer tracks in all habitats.

2. test for differences in deer-use intensity as indicated by track counts among the four habitat types in each area, so as to determine which types are receiving heaviest use.
3. quantify the relationships between snow interception (dependent variable) and canopy closure, tree height, crown length, mean dbh, and total dbh (independent variables) in the eight habitat units described above under (1).

Sample sizes have been chosen, based on available data from other studies, to meet the following objectives: 1) for mean snowpack depths, the objective will be to detect differences of 10 cm between habitat types with 95% confidence (pilot data from Haney, B.C., and southeast Alaska); 2) for differences in frequency distributions of snowpack depths, the objective will be to detect differences of 20% in the proportion of depth samples from each habitat type that fall below some threshold level (e.g. 37 cm, which is 70% of deer chest height), with 80% confidence; 3) for mean snow density to 55 cm, the objective will be to detect differences of 5% with 95% confidence; and 4) for track counts in the deer study area, the objective will be to detect differences of three to four tracks per sampling unit with 90% confidence. Track means per unit in the various habitat types are expected to range from 0 to 12 or more.

No preliminary data on forage are available that fit the conditions of our study. However, such data are expected to be highly variable within any habitat type, and sampling effort will be restricted by time available. The number of forage samples to be taken will be determined more by feasibility than by precision.

3.1.2 Variables

3.1.2.1 Snow

Total snowpack depth will be measured, as will fresh snow depth whenever fresh snow can be distinguished from older snow. Snow interception will be estimated as the difference between fresh snow accumulation in the open and

fresh snow under the trees, stratified by elevation. Snow density to 55 cm (mean brisket height for black-tailed deer) will be measured with the use of one section of a Stevenson snow tube.

3.1.2.2 Deer use

Deer use will be assessed by the number of fresh tracks (i.e., those made since the last snowfall) per sampling unit, scaled by the number of days since the last snowfall.

3.1.2.3 Available forage

Visual estimates of percent ground cover of available forage below 1.5 m height will be made by species for all herbs, shrubs, and trees. For mosses, a single cover estimate for all species will be taken.

For selected forage species (Table 1), quadrat densities and size measurements will also be taken. For most shrubs and for conifers, < 2 m tall, stem basal diameters or branch diameters will be recorded; for ferns, frond lengths will be measured; and for arboreal forage lichen litterfall, percent cover on 2-m^2 quadrats will be estimated. For heavily browsed shrubs, total length will also be measured; and for "broomed" shrubs (especially Vaccinium parvifolium) that are almost buried by snow, the number of stems or twigs per individual plant that emerge from the snow will be counted and the length of the longest twig above the snow will be recorded.

Regression equations developed from samples of all species collected in the study area during winter 1983/84 will be used to predict forage biomass from these data (Table 1).

3.1.2.4 Overstory

For snow interception analysis to support more detailed work (Section 3.4), tree height, live crown length, and dbh will be measured with standard forestry techniques, and canopy completeness will be measured with both a modified moosehorn (Robinson 1947) and a hemispherical photograph. Canopy completeness was defined by Bunnell et al. (1984) as the completeness of the forest canopy when viewed from a sampling point beneath, and differs from the

TABLE 1 Forage species to be measured

Latin name	Common name	Biomass equation	Y variable Type	Y variable Units	X variable Type	X variable Units	n	r^2	$S_{Y.X}$
		(A) Rooted conifers <2 m tall							
Pseudotsuga menziesii	Douglas-fir	Ln(Y) = -2.194 + 2.226 Ln(X)	Foliar biomass *	Grams	Basal diameter	Millimetres	24	0.96	0.42
Taxus brevifolia	Western yew								
Thuja plicata	Western redcedar	Ln(Y) = -1.643 + 1.909 Ln(X)	Foliar biomass *	Grams	Basal diameter	Millimetres	24	0.81	0.89
Tsuga heterophylla	Western hemlock	Ln(Y) = -1.812 + 2.218 Ln(X)	Foliar biomass *	Grams	Basal diameter	Millimetres	24	0.94	0.44
		(B) Conifer litterfall							
Pseudotsuga menziesii		Ln(Y) = -0.657 + 1.639 Ln(X)	Foliar biomass *	Grams	Stem diameter	Millimetres	24	0.82	0.51
Taxus brevifolia									
Thuja plicata		Ln(Y) = -2.232 + 2.410 Ln(X)	Foliar biomass *	Grams	Stem diameter	Millimetres	25	0.81	0.88
Tsuga heterophylla		Ln(Y) = -0.488 + 1.795 Ln(X)	Foliar biomass *	Grams	Stem diameter	Millimetres	24	0.90	0.46
		(C) Shrubs							
Amelanchier alnifolia	Saskatoon								
Cytisus scoparius	Scotch broom	Ln(Y) = -2.785 + 2.662 Ln(X)	Above-ground biomass	Grams	Basal diameter	Millimetres	24	0.96	0.44
Gaultheria shallon	Salal	Ln(Y) = -2.596 + 2.37 Ln(X)	Foliar biomass	Grams	Basal diameter	Millimetres	24	0.89	0.57
Mahonia nervosa	Oregon grape	Ln(Y) = -3.221 + 2.916 Ln(X)	Above-ground biomass	Grams	Basal diameter	Millimetres	24	0.82	0.59
Paxistima myrsinites	Oregon boxwood								
Prunus emarginata	Bitter cherry	Ln(Y) = -2.346 +2.402 Ln(X)	Stem biomass	Grams	Basal diameter	Millimetres	16	0.96	0.29
Ribes sanguineum	Red-flowering currant								
Rosa sp.	Wild rose	Ln(Y) = -3.692 + 3.277 Ln(X)	Stem biomass	Grams	Basal diameter	Millimetres	24	0.92	0.46
Rubus leucodermis	Black raspberry	Ln(Y) = -3.223 + 2.527 Ln(X)	Stem biomass	Grams	Basal diameter	Millimetres	24	0.82	0.56
Rubus parviflorus	Thimbleberry								
Rubus spectabilis	Salmonberry								
Vaccinium parvifolium	Red huckleberry	Ln(Y) = -0.367 + 2.040 Ln(X)	Available stem biomass **	Grams	Basal diameter	Millimetres	137	0.89	0.47
Vaccinium alaskaense and V. ovalifolium	Blueberries								
		(D) Ferns							
Blechnum spicant	Deer fern	Ln(Y) = -6.352 + 1.654 Ln(X)	Above-ground biomass	Grams	Frond length	Centimetres	24	0.89	0.33
Polystichum munitum	Sword fern	Ln(Y) = -7.862 + 2.135 Ln(X)	Above-ground biomass	Grams	Frond length	Centimetres	24	0.90	0.52
		(E) Lichens							
Alectoria spp., Bryoria spp., Usnea spp.									

* Conifer "foliar biomass" includes needles and twig segments bearing the needles.

** Available red huckleberry stem biomass is defined as stem segments <2.2 mm minimum diameter.

forester's usual definition of crown closure, which is the proportion of ground area covered by the vertical projection of tree crowns. In a given stand, mean canopy completeness is always less than mean crown closure.

3.1.2.5 Weather

Weather variables to be recorded are half-hourly temperature (^{o}C), relative humidity (%), and maximum wind speed (m/second); plus daily minimum and maximum temperature, minimum and maximum relative humidity, mean wind speed, and mean wind direction.

3.1.2.6 Site features

Slope, aspect and elevation will be recorded at each sampling point.

3.1.3 Sources of variation

Although we cannot control the sources of variation in this study as would be possible in a designed experiment, we will take account of the following sources in our analyses of sample data:

1. for snowpack, deer use, and forage availability comparisons: stand type (clearcut, old growth, spaced immature, and unspaced immature) and area (Dunsmuir and Jump Creek)
2. for snow interception analysis: elevation, canopy completeness, tree height, live crown length, and dbh.

3.1.4 Design and layout

We assume that deep, soft snow restricts deer to fewer habitats than any other weather condition (i.e. these are "critical" conditions). When snow crusts or melts, more freedom of habitat choice is available.

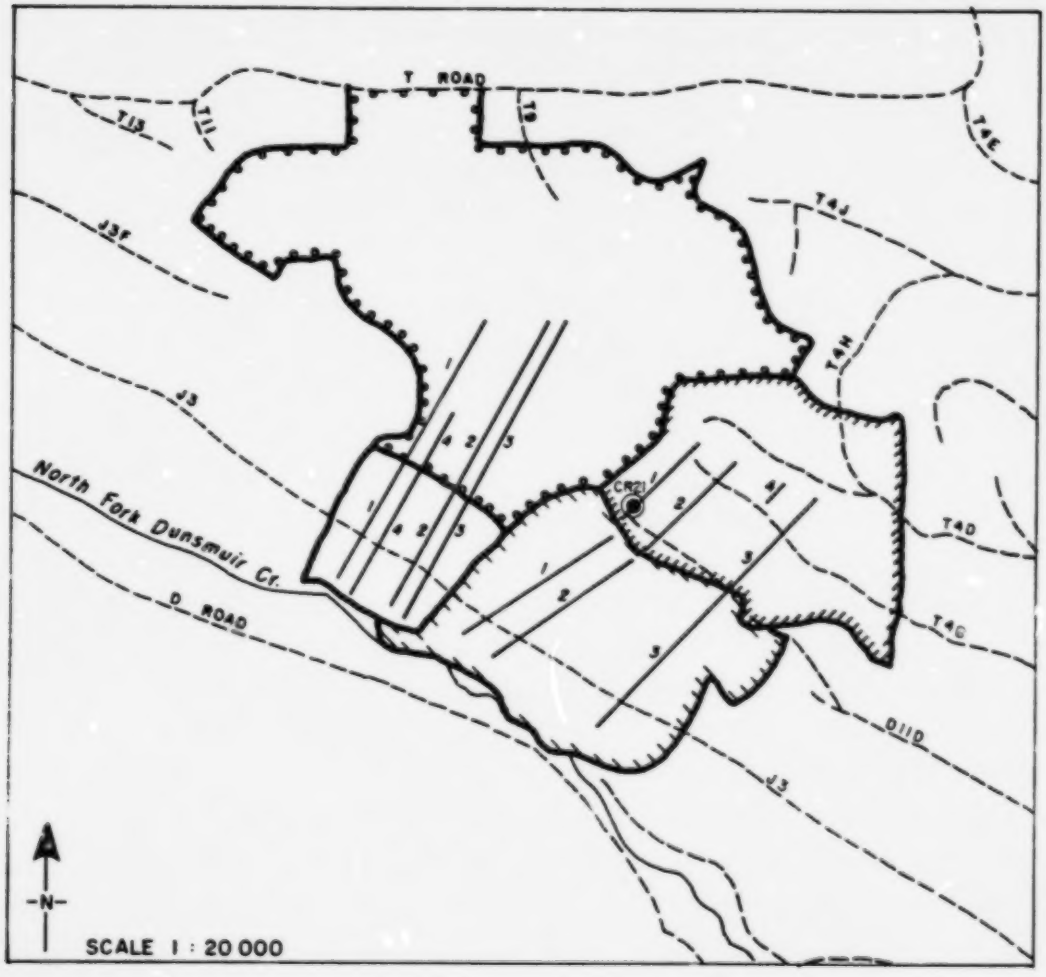
For comparisons of snowpack and forage conditions among stand types, four habitat types have been chosen for sampling in each of two study areas - Dunsmuir Creek and Jump Creek - both of which are tributaries of the South Nanaimo River. In each study area, the habitat types are adjacent and similar in slope and aspect, and all are used by deer at some time of the year. In Dunsmuir Creek, the four types consist of: 1) old-growth

Douglas-fir and western hemlock (> 300 years); 2) open clearcut; 3) a 27-year-old spaced Douglas-fir stand; and 4) a 12-year-old unspaced Douglas-fir stand (see Figure 2). In Jump Creek, the four types consist of: 1) old-growth Douglas-fir and western hemlock; 2) open clearcut; 3) a 20-year-old unspaced Douglas-fir stand; and 4) a 20-year-old spaced Douglas-fir stand (Figure 3). In both Dunsmuir Creek and Jump Creek the unspaced young-growth stands are more open-canopied than the spaced stands adjacent.

In each type, 60 snow sampling points are located, spaced 25 m apart on transects running upslope. Thirty of the 60 (alternate points) are square snow stations 1 m^2 in area, that were cleared of debris and vegetation before the soil surface was smoothed. These stations are marked with a 1.2-m tall cedar stake located 1 m east of the snow station centre point. The top portion of each stake is painted yellow, except for those at the end stations on each transect, which have blue tops. In one case a log prevented placing the sampling station exactly at the 50 m point, so the station was moved to the nearest suitable point. The 50 m point was then marked with a normal yellow stake, and another stake, painted blue and yellow, was placed 1 m east of the relocated snow station. The 30 unmarked sampling points are midway between the snow stations.

The transects on which the snow stations lie were located subjectively, but without bias to habitat conditions. Initial plans called for at least three transects in each type with the exact number being dependent on the upslope width of the habitat type. The two outer transects in each type were to be located between 50 and 100 m from the western and eastern edges of the type. The central one or more transects were to be spaced approximately evenly, and the exact location for each was to be chosen to cross a convenient tie-point on a logging road.

This plan proved to be feasible in all but one type, although spacing between transects varied more than expected because existing pellet-group transects were followed in a few cases in order to avoid flagging and painting extra lines nearby. Because the unspaced area available for sampling in Jump Creek was small, the 30 snow stations were located on 10



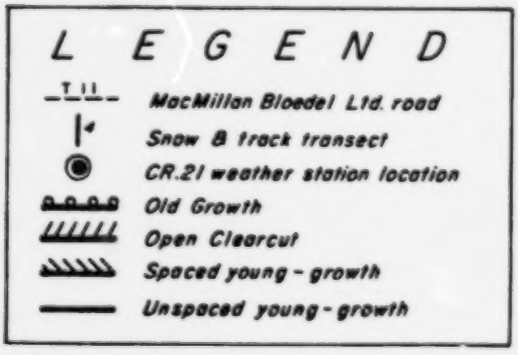
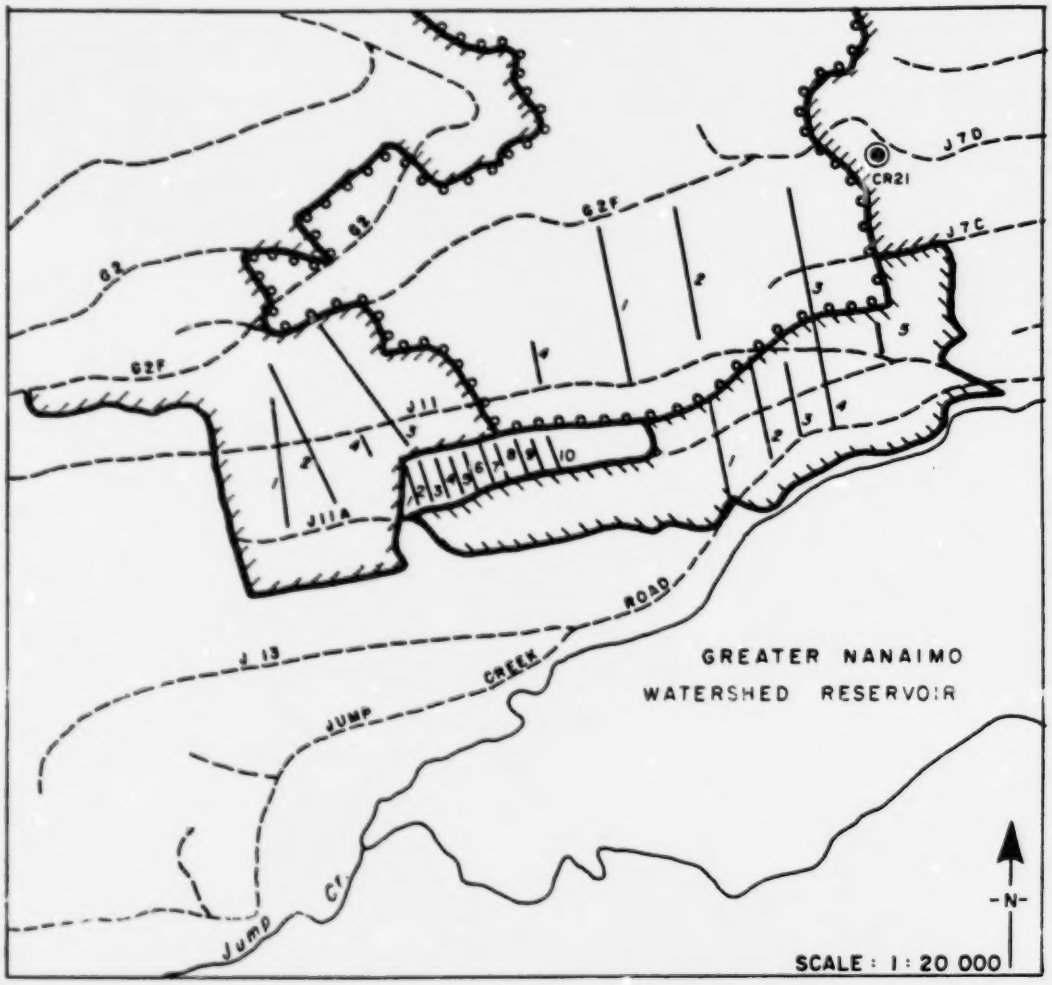


FIGURE 2 Locations of habitat types, transects,and CR-21 weather stations in Dunsmuir Creek.



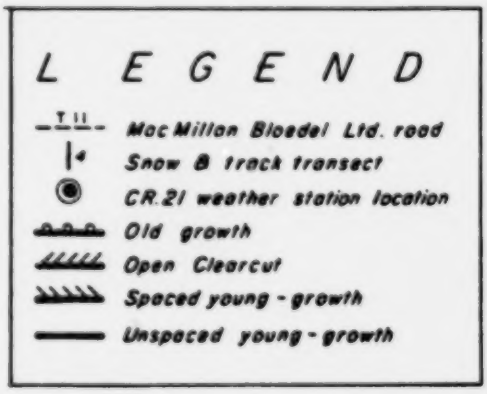


FIGURE 3 Locations of habitat types, transects,and CR-21 weather stations in Jump Creek.

very short transects spaced only about 50 m apart across the slope. This pattern will not affect snow and overstory sampling, but the closeness of the transects makes it likely that a substantially higher number of individual deer tracks will cross more than one transect in this habitat type than in other types where transects are spaced more widely. Therefore, tracks will only be counted on four transects in the unspaced young growth - the first, fourth, seventh, and tenth as one proceeds east through the type.

Approximate transect locations are shown in Figures 2 and 3. Detailed maps and descriptions of transects and stations can be found in the Appendix (p. 50). Each transect was marked with an aluminum tag at the roadside tiepoint and at each end. A yellow and blue "bull's-eye" was painted on a log, stump, tree, or rock at each roadside tiepoint, and all transects were flagged with fluorescent pink tape.

The 30 transect segments running uphill to the cleared snow stations in each type will be the sampling units for deer track counts.

3.1.4.1 Snow and deer use sampling

Sampling will begin when open sites on the valley floor in Jump Creek or Dunsmuir Creek are covered by 2.5 cm or more of snow. If snowpack depth in the old growtn at valley bottom is less than 7.5 cm, only fresh snow depth, total snowpack depth, and visible tracks will be measured. If snow in the lower portion of the old-growth stand in either area averages 7.5 cm, all variables, including available forage, will be measured.

After each of three or more storms that result in at least 5 cm snow accumulation in the lower old growth (enough to cover old deer tracks in the snow), the sampling procedure will be as follows:

During the two days after a storm, all transects in both study areas will be surveyed. Sampling will be concentrated in one drainage (e.g. Jump Creek) the first day and the other drainage on the second day (see Section 4 for area priorities). Deer tracks crossing each 50-m transect segment will be counted. Sampling of all the types in one drainage on the same day will minimize variations in track density due to the time since snowfall,

and track-counts should be indicative of the density of deer in each type. This assumes that there are no major differences among types in the average distance walked by individual deer after snowstorms, an assumption that is supported by previous field observations and that will be checked by intensive radiotelemetry observations of transmitter-equipped deer (Section 3.2).

At each snow sampling point, snowpack depth will be measured to the nearest centimetre with an aluminum rod. If a single snowfall has occurred since the last sampling occasion and fresh snow can be distinguished from older snow, the depth of fresh snow will be measured at all stations. If there have been several snowfalls, periods of thawing, or winds that have redistributed snow, no fresh snow depth measurement will be taken. Snow density to 55 cm or to the ground, whichever is least, will be measured at every second snow station.

The following measurements have been taken at each snow station: slope; aspect; elevation; and - for all trees having a portion of their crown foliage within 5 m of a vertical projection of the snowboard location - dbh, total height, and live crown length. Directly above the snowboard location, an overstory photograph was taken with a Nikkor 8 mm fisheye lens. The developed photographs (17.5-cm diameter prints) will be sampled to determine canopy completeness, i.e., the proportion of sky obscured by trees will be determined, in 5^{o} arcs up to 25^{o} away from the zenith, with a dot-count grid having 50 points in each 5^{o} segment. A moosehorn will be used to take another measure of canopy completeness at the same points.

For us to make valid comparisons of conditions among habitat types, there must be no important changes in snow or forage conditions while the sampling is going on. Therefore, if sampling is not complete before there is a new snowfall of more than 2 cm, or a heavy rain, or a very warm sunny day that results in rapid melt, the planned sampling will be cancelled. This is another advantage of sampling all habitat types in one drainage in one day - if the weather then changes overnight, at least one group of habitat samples will be available for analysis.

3.1.4.2 Forage sampling

Each time the snow sampling is conducted, forage availability differences among habitat types will be assessed in two ways. First, understory abundance will be visually estimated on a 1 x 5 m quadrat running uphill from the cedar stake at each station. The lower left (southwest) corner of the quadrat will be at the stake. Other corners will be marked with stake flags. Percent ground cover of all herbs, shrubs, trees, and forage lichen litterfall below 1.5 m above the ground or snow surface will be recorded in the following classes: 0, 0.1-2%, 2-5%, 5-10%, 10-20%, 20-30%, and so on in 10% classes. An average height will also be recorded for each shrub species.

To supplement the percent cover estimates, forage plant density counts and size measurements will be recorded on a 2-m^2 quadrat at each snow station. The quadrat will lie with its southwest corner at the station stake (Figure 4). The 2-m^2 area covered by this quadrat will overlap the 5-m^2 quadrat on which percent cover estimates will be recorded. For each forage plant rooted in the quadrat, a size measurement will be recorded for future use in the calculation of forage biomass by species. For all live shrubs and for live conifers less than 1.5 m tall, stem diameter at the point the stem emerges from the snow will be measured with calipers to the nearest 0.1 mm. For conifer litterfall that includes green foliage on the quadrat, branch diameter will be measured at the edge of the quadrat, or, if a large amount of foliage on the main branch lies outside the quadrat, at the base of any branch or twig bearing the green foliage that lies within the quadrat (see Figure 5). Percent cover of arboreal forage lichen below 1.5 m will be estimated on and above each quadrat. Most of this will be litterfall, but when the snowpack is sufficiently deep, some lichen on tree trunks and lower branches may be available within 1.5 m of the snowpack surface. For deer fern and sword fern, frond lengths will be measured with a flexible tape measure.

On some quadrats, salal or other shrubs will be so abundant that measurement of stem diameters for every stem on a 2-m^2 area would take far more time than is available. In those cases, the quadrat size will be reduced to 0.25 m^2, 0.5 m^2, or 1 m^2 for salal sampling. At least 10

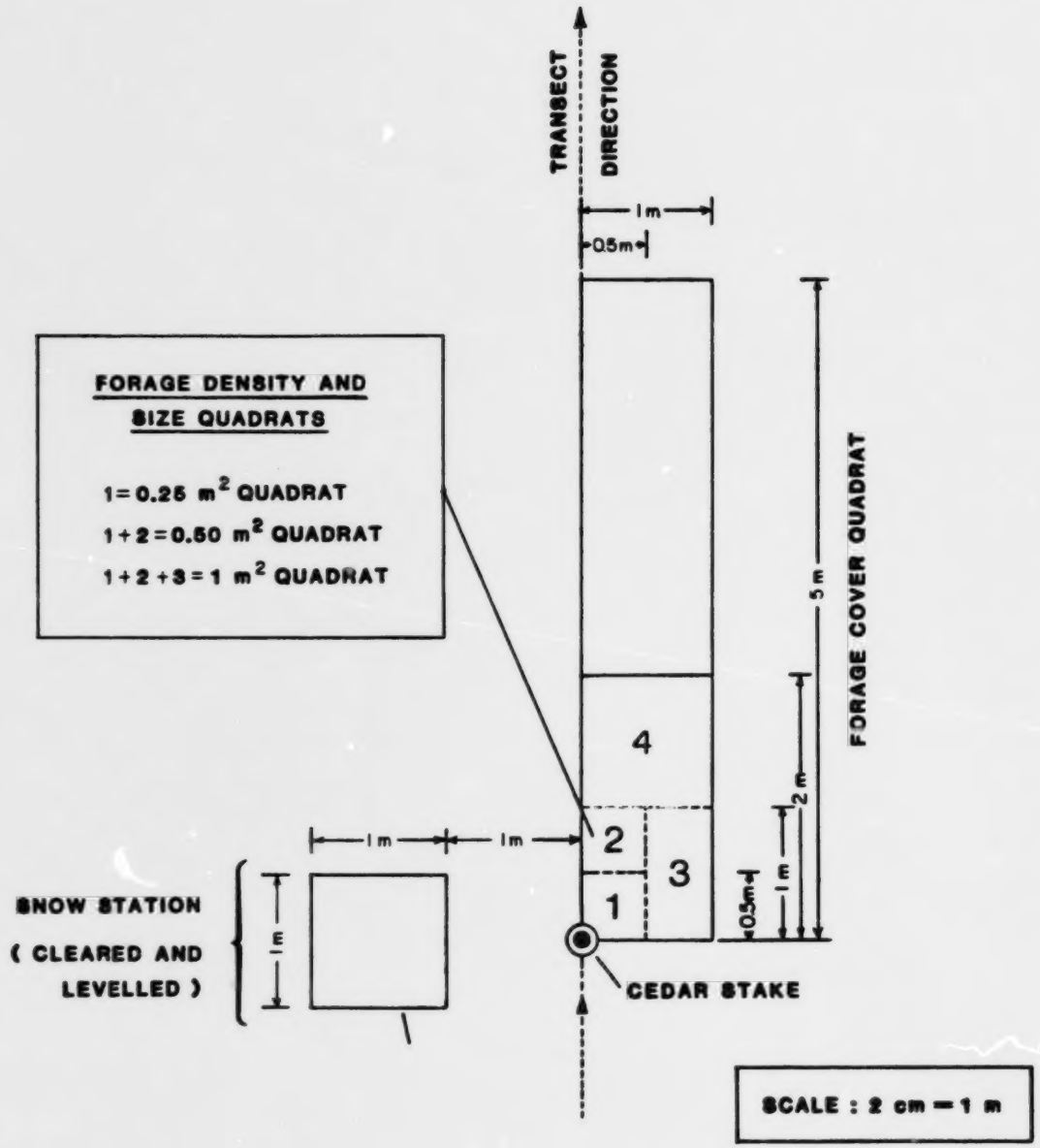


FIGURE 4 Snow station and forage quadrat arrangement on transects.

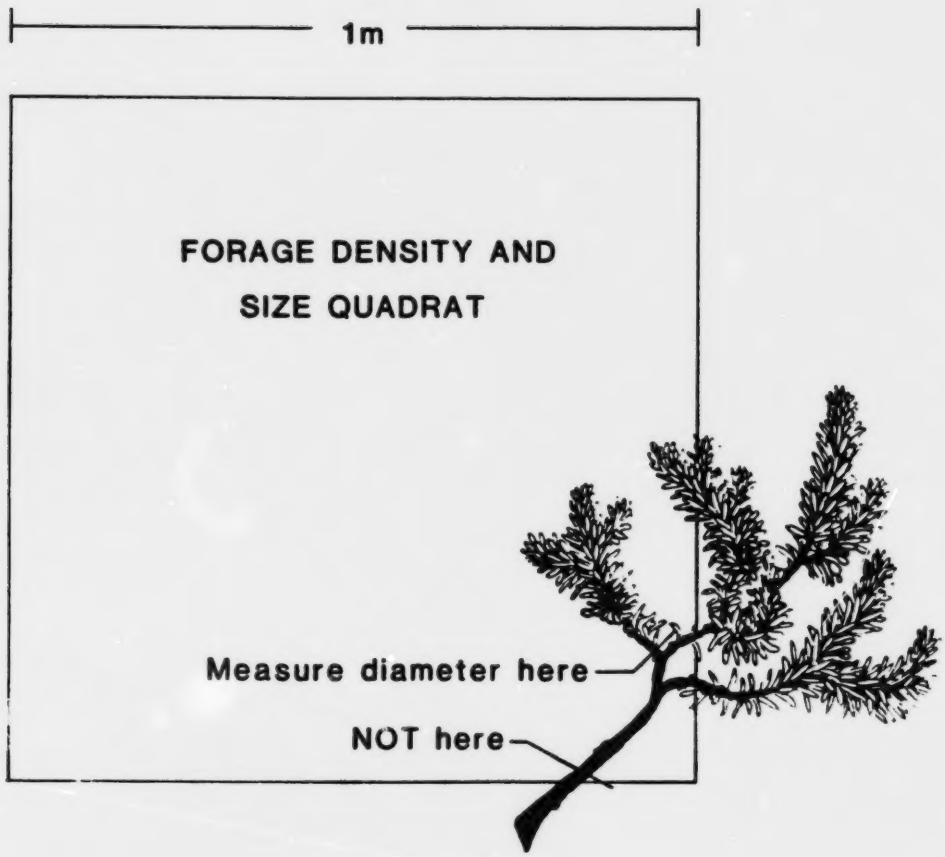


FIGURE 5 Measurement point example for conifer litterfall lying partially on a quadrat.

stems will be measured on the smaller quadrats. The same procedure will be followed for other shrub species that attain densities greater than 10 stems per 0.5 m^2.

On many red huckleberry plants, and potentially on other species, heavy browsing pressure has repeatedly removed all or most of the distal twigs, resulting in a "broomed" form, and has presumably affected growth rates of the plants and the proportion of available browse on each plant. Regression equations will therefore be stratified to account for variable browsing histories among plants, with the total length of red huckleberry plants measured in addition to stem diameters.

Further, for those red huckleberry plants on which the broomed portion is just protruding from the snow surface, and for which many small twigs would therefore have to be measured, the sampling approach will again be modified. In these cases, the number of twigs protruding through the snow will be counted, the length of the longest stem above the snow measured, and the snow excavated around the main stem to a point just below the junction of the branches bearing the protruding twigs, where a single diameter measurement will be taken.

If more than 50% of a quadrat is occupied by a rock, a tree bole, fresh woody debris, or other substrate unsuitable for plants, the 2-m^2 quadrat will be moved uphill to avoid the obstacle, but still kept within the larger 1 x 5 m quadrat. If all leaves of a live salal plant are buried in snow or have been eaten, the plant will not be measured, because salal stems are not commonly eaten.

Detailed instructions for forage plant sampling are included in the Appendix (p. 68).

3.1.5 Measures and records

All data will be recorded on field sheets designed for direct keypunching. Copies of field forms are included in the Appendix.

3.1.6 Planned analyses

The snowpack depth and density data will be summarized to provide

descriptive statistics and graphical displays of differences among stands. The following hypotheses will also be tested:

1. Mean snowpack depths and densities rank as follows among habitat types:

   clearcut > unspaced young growth > spaced young growth > old growth.

2. Within a study area, the frequency distribution of snowpack depths is independent of habitat type. (Snow samples will be grouped into three classes for this analysis: 0-11 cm, 12-24 cm, and > 25 cm.)

Analysis of variance (ANOVA) or equivalent non-parametric techniques will be used to test the hypotheses listed above under (1). If significant treatment effects occur, orthogonal contrasts will be used to test for differences among means. The appropriate ANOVA table is shown in Table 2. The treatment (habitat type) and block (Dunsmuir and Jump Creeks) effects are fixed, and snow station effect is random. Stations are nested in blocks and habitat types. The orthogonal coefficients for contrasts between stand types are shown in Table 3.

ANOVA will also be used to test the hypothesis that mean deer-track density is significantly different among types, and orthogonal contrasts will determine whether the types with the least snow have more deer use.

After testing among habitat types for differences in snowpack and deer use, simple correlation analysis will be used to test whether deer track densities are correlated to snowpack depths and densities when samples from all habitat types and all sampling occasions are pooled.

If snowpack depths and densities do not explain a large proportion of the variation in track densities, the possibility of using multivariate analysis to identify other key environmental variables, such as forage abundance and elevation, will be discussed with a Research Branch statistician.

The hypotheses concerning the relative proportions of shallow snow samples will be tested using the G-test of independence for two-way tables, or log-linear models for multi-way frequency tables (Sokal and Rohlf 1981). Multiple regression analysis will be used to evaluate the relationship between overstory characteristics and fresh snow depths.

Differences in forage availability among stands will also be tested using

TABLE 2 ANOVA table for analysis of snowpack depth data

Sources	Expected mean squares	df	F tests
Blocks, B	$\sigma^2_\varepsilon + 240\phi_B$	1	MS_B/MS_E
Habitat types, A	$\sigma^2_\varepsilon + 120\phi_A$	3	MS_A/MS_E
Interaction, B x A	$\sigma^2_\varepsilon + 60\phi_{BA}$	3	MS_{BA}/MS_E
Snow stations, E(BA)	σ^2_ε	472	
Total		479	

TABLE 3 Orthogonal coefficients for analyzing differences among habitat types in snowpack depths

	Stand type			
Contrast	Old growth	Thinned young growth	Unthinned young growth	Clearcut
C_1	+3	-1	-1	-1
C_2	0	+2	-1	-1
C_3	0	0	+1	-1

ANOVA or equivalent non-parametric tests, and will be correlated with deer track densities. No pre-planned comparisons of forage abundance will be made, so multiple range tests will be conducted if differences in treatment means are indicated.

3.2 Winter Home Range Selection

3.2.1 Objectives

The objective of this portion of the study is to monitor activity patterns, forage, and home range selection trends during winter.

3.2.2 Variables

3.2.2.1 Location

Location is derived from a minimum of three bearings from known locations which, when drawn on a 1:20 000 MacMillan Bloedel Ltd. forest cover map, will produce an error polygon that estimates the animal's location.

3.2.2.2 Activity

Activity will be monitored with motion-sensing radio collars (Telonics, Inc.). These transmitters change the period of their signal according to the orientation of the collar on the animal and the animal's movement. These changes of signal period can be continuously monitored through a telemetry receiver, digital processor, and paper chart recorder (Rustrak), thereby generating the pattern of activity of that particular animal.

3.2.2.3 Stand type

Stand types will be the ones used on MacMillan Bloedel Ltd.'s 1:20 000 forest cover maps, supplemented with ecosystem and successional stage types from a map prepared during 1984.

3.2.2.4 Snow

Snowpack monitoring stations at various sites throughout the study area will be used to monitor the magnitude of snowpack during telemetry sessions. All snowpack monitoring stations are in open clearcuts and consist of five

3-m painted poles.

3.2.2.5 Weather

Weather (half-hour temperatures, half-hour humidity, highest 30-second-average wind speed each half hour, and mean daily direction) will be continuously monitored by two micrologger weather stations (CR-21's, Campbell Scientific) located in clearcuts in the Jump and Dunsmuir Creek study areas.

3.2.3 Sources of variation

3.2.3.1 Sex and age

All animals radio collared in the study area are adult females (> 1.5 years), so any variation due to age and sex should be minimal.

3.2.3.2 Animal condition

Animal condition is almost impossible to determine in our study areas because the dense cover severely limits use of visual estimates, and re-immobilization of collared animals (to use blood parameters) is virtually impossible.

We recognize animal condition is a possible confounding factor, but we are unable to control it.

3.2.3.3 Predation

Since the removal of six wolves in 1982/83, signs of wolf presence (fresh scats or tracks) have greatly diminished. If any new packs of animals move into our study area, Ministry of Environment animal control officers will attempt to remove them.

3.2.4 Design and layout

3.2.4.1 Monitoring sessions

We plan to conduct 3-day monitoring sessions on one or two radio-collared deer after snowfalls that cause deer to shift locations (Section 3.3), and to routinely locate all deer once every 7-10 days. For priorities with other winter work see scheduling decision key, p. 80.

3.2.4.2 Locations

Locations on radio-collared deer will be taken every two hours during intensive telemetry sessions. This will generate approximately 36 locations per deer.

3.2.4.3 Activity

Activity will be monitored during intensive telemetry sessions with motion-sensing collars and a paper-chart recorder (see Section 3.2.2.2). Three deer in each drainage have motion-sensing collars. The receiving unit will switch between deer every six minutes. This means each animal's activity will be monitored six out of every eighteen minutes.

3.2.4.4 Forage

After the intensive monitoring periods, eight to ten fresh pellet groups will be collected in the habitats used by as many of the intensively monitored animals as time permits. These pellet groups will be analyzed by fecal fragment analysis to determine forage preference.[4]

3.2.4.5 Snow

The snowpack monitoring stations previously described (see Section 3.2.2.4) are located along roads used for radiolocating intensively monitored animals and will be checked throughout the monitoring periods to document the average local snowpack depth.

3.2.5 Measures and records

All radiolocation data is recorded on field sheets (see Appendix, p. 67). The resulting error polygon and habitat data from 1:20 000 forest cover maps are coded onto fortran data sheets for keypunching (after Janz et al. 1980). Activity data is recorded on paper tape (Rustrak 300).

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[4] Analysis will be conducted by Wildlife Management Services, Washington State University, Pullman, Wash.

3.2.6 Planned analysis

Due to the large amount of variability in habitat selection strategies apparent in mild winters[5], we feel it necessary to document the winter habitat selection trends of as many deer as possible in a deep-snow winter. The approach to the data will be mainly qualitative as opposed to the quantitative approach in Section 3.3. Analysis will be simple comparisons of home range (size, location, topographic features, habitat types) with forage preferences and weather conditions of as many deer as possible during the three previously mentioned periods. This will also help in the selection of suitable animals for the phase of the program described in Section 3.3.

3.3 Habitat Selection in Response to Weather Events

3.3.1 Objectives

This portion of the winter program is designed to investigate the advantages that deer gain by changing their patterns of habitat use in response to winter weather events. By identifying the habitat conditions favoured by deer when the weather deteriorates or improves suddenly, we hope to determine the forest stand features that should be enhanced through stand management.

As explained in more detail later, we have developed a set of hypotheses about what attracts deer to new locations when the weather changes, including better forage in the new area, better snowpack conditions, or a combination of the two. The weather events that are candidates for study include:

1. snowfalls of more than 7.5 cm in a 24-hour period;
2. windy conditions that generate large amounts of conifer and lichen litterfall;
3. the formation of strong crusts in the snowpack;
4. melt of more than 10 cm of snow as measured at roadside snow

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[5] D. Doyle, R. Davies, B. Mason and L. Peterson. 1983. Annual progress report 1982/83, EP 923. Unpubl. rep., B.C. Min. Environ., Nanaimo, B.C. 18p.

stations in a 48-hour period, particularly when this changes forage availability dramatically in some habitats; and

5. the first appearance of the ground surface in clearcuts after 14 days or more of continuous snow cover.

We hope to sample the "event responses" of one or more deer on at least three occasions, and more often if weather conditions permit.

3.3.2 Variables

Deer locations taken by radiotelemetry will allow us to distinguish the short-term home ranges that are occupied before and after weather events. We hypothesize that a change in location that takes place coincident with a weather event indicates a preference for the food or snow conditions found in the post-event location, as compared to what is available after the event in the previously occupied location.

When a weather event (as defined in the previous section) appears to cause a deer to change the location of its short-term home range, our hypotheses concerning the driving force(s) behind the move can be phrased as three general statements:

1. The deer moved to decrease its rate of energy output during normal activity (feeding, bedding, and associated travel);
2. The deer moved to increase its rate of energy intake from forage; and
3. The deer moved to improve its net energy status.

We would like to test all three hypotheses, but calculation of net energy status requires measurement of absolute values for both energy input and energy output so that the difference between the two can be determined. Those absolute values cannot be obtained in this study. Relative differences among habitats in intake or output individually can be assessed with indices suited to statistical testing, so only hypotheses concerning these two factors in the net energy equation are presented here.

Energy output is assumed to be most influenced by deer sinking depth in snow when other factors, such as slope angle, number of obstacles, and gait,

do not vary greatly (Parker 1983). Unfortunately, we have found no index that is suitable for estimating sinking depths of black-tailed deer in coastal snow conditions (R.S. McNay and F.L. Bunnell, pers. comm.). Snow density to the ground or brisket height, whichever is less, comes closest, so we will use snowpack depth and density to the lesser of 55 cm or the ground as our indices of habitat suitability.

Our null and alternate hypotheses will be:

H_o: Snowpack depth and density in the location occupied after the event = Snowpack depth and density in the location occupied before the event.

H_1: Snowpack depth and density in the "after" location < Snowpack depth and density in the "before" location.

Snowpack depths will be expressed both as means and as the proportion of samples from each home range that fall into three depth classes: 0-11 cm, 12-24 cm, and > 24 cm, or other classes based on proportions of brisket height if the snowpack exceeds 25 cm on average.

Although the preferred variable for comparing energy intake between locations would be metabolized calories per unit time, the measurement of forage intake by species is not feasible. Using literature values for dry-matter digestibility (Rochelle 1980) for some species, we may be able to rank the apparent available energy in each location. Failing this, the standing crop of forage plants below 2 m height is a gross index of relative potential energy intake rate in each location.

The hypotheses will be:

H_o: Forage plant biomass or available metabolizable energy (ME) (.88 DDM) in the "after" location = Forage plant biomass or in the "before" location.

H_1: Forage in the "after" location > Forage in the "before" location.

Tests of these hypotheses will be conducted for forage species individually, for forage types (ferns, shrubs, conifers, arboreal lichens), and for all forage species together.

3.3.3 Sources of variation

In this portion of the study, we will investigate the relative importance of snowpack depth, snowpack density, and forage abundance in determining deer habitat use - not what causes variation in snowpack and forage, so only qualitative descriptions of stand characteristics will be employed to assess the sources of variation.

3.3.4 Design and layout

There is little in the literature concerning the movements and habitat selection of specific blacktail deer in response to deep snowpacks, although extensive field observations have been taken by some individuals. Because of the lack of background knowledge on which to base predictions of deer responses to deep snow, and because our study area is subject to extremely variable winter weather, we have emphasized flexibility in designing our approach to "event response" tests so that we will be able to adapt our methods to as many patterns of deer behaviour and weather as possible.

We begin with two alternate approaches to investigating event responses. The approach to be used after a specific weather event has occurred will depend on the pattern of deer behaviour and habitat use that is revealed by radiotelemetry. If the deer chosen for study is a "roamer", wandering through extensive portions of one or more habitat types in the course of a day or two to feed and rest, and probably using several different bedding sites, we will use a "macrohabitat" sampling approach. If the deer is a "sitter" that feeds and rests for 12-24 locations in a restricted area (such as a small portion of one habitat type), and especially if it returns to the same bed repeatedly, we will use a "microhabitat" approach. These alternate approaches arise from the possibility that, under very critical conditions, such as deep (>40 cm) and powdery snow, some deer (or perhaps even all deer) will restrict their activities to very small areas that provide the minimum required forage and thermal and hiding cover in their immediate vicinity; while, under other conditions, deer will continue their typical pattern of roaming throughout an area that contains a heterogeneous distribution of food and cover resources, not focussing their activities in one restricted locale.

Each approach carries its own advantages and risks, as will be explained in the next two sections. The choice of method in a given instance will be left up to the field team, whose experience and radiotelemetry results will guide their choices.

3.3.4.1 Macrohabitat sampling

Macrohabitat sampling can be used for two categories of roaming deer: those animals for which home ranges during mild winter conditions were determined during the 1982/83 and 1983/84 winters; and any deer for which pre-event and post-event ranges can be mapped this winter. Methods will be as follows.

Before, during, or immediately after a suitable weather event, intensive telemetry of as many deer as possible will be initiated. If the weather event can be forecast with sufficient confidence, telemetry will begin up to two days before the event is expected, and will include bi-hourly locating and 24-hour alternating activity monitoring (6-minute cycles of continuous activity per deer) for three deer equipped with tip-switch collars. Intensive telemetry will continue throughout the duration of the event and up to two days after the weather stabilizes - at least until the pattern of locations and activity of a suitable study animal indicate that it has moved to a new area as a result of the weather event and is foraging in the area. When the new area has been defined with 12-24 locations, habitat sampling will be conducted, providing the weather has not changed drastically in the meantime.

Alternatively, if telemetry is not initiated in time to establish the immediate pre-event range of any of the deer equipped with tip-switch collars, habitat conditions in last year's winter home ranges will be contrasted with the post-event ranges for one or more deer when heavy snowfalls occur. In most cases, deer in our study area are very traditional in their home range use; we assume, therefore, that without snow the home ranges for deer that were intensively monitored during the mild 1982/83 and 1983/84 winters would be the same this year. This approach does not allow the testing of habitat responses to improved habitat conditions (such as

snowmelt), but it has the great advantage of not relying on accurate weather forecasting because telemetry can begin during or even after a snowstorm. It can only be used on deer that were monitored intensively by telemetry during one of the 1982/83 or 1983/84 sessions.

Under either alternative, the habitat sampling methods described in this section will only be used if the deer to be studied shows a pattern of roaming after the weather event. We assume that roaming behaviour indicates the deer is finding food that is distributed throughout the area encompassed by the deer's movements. In sampling habitat conditions, we will attempt to assess the average conditions of snow and food, as well as the variability in both features throughout the areas used by the deer before and after the weather event, not just in the immediate vicinity of the radiotelemetry locations.

Once pre-event and post-event ranges have been determined for several deer, the two areas for each animal will be compared on a map to establish whether a significant shift in its locations did occur. Several types of location shifts could indicate the selection of a special habitat by a deer in response to the weather. Such types of shift include a complete separation of pre-event and post-event ranges, a small overlap in the two ranges, and a post-event concentration of locations within a small (< 30%) portion of the pre-event range. When a significant shift in locations is noted, the pre-event and post-event ranges will be plotted on 1:10 000 colour airphotos, as will the boundaries of habitat types within each home range. Habitat types will typically be ecosystem and successional stage types from a map prepared during summer 1984, but additional criteria such as slope, aspect, and canopy closure will be used to further distinguish types when appropriate.

With ranges, telemetry locations, and habitat types plotted on photos, habitat samples will be assigned. In each of the two ranges, 120 samples of snowpack depth, 30 samples of snow density to the ground or 55-cm depth, and 30 samples of forage will be taken. Because each range may contain two or more habitat strata (types), the number of snow and forage samples to be taken in each stratum will be proportionally allocated based on the

proportion of telemetry locations that fall in each stratum.

Sampling points in each stratum will be located systematically on transects running uphill through the stratum. There will be at least three transects in each stratum needing six or more forage samples, and one transect when fewer than six forage samples are required. No samples will be taken within 50 m of the boundary between two strata, but sampling will extend to the range boundary. Sampling points will be spaced evenly at 50-m intervals for forage and 25 m for snowpack characteristics.

Because strata will be irregularly shaped, transect lengths within a stratum will vary. The transect arrangement is only used because it makes it easy to locate sampling points in the field; it is not a cluster sampling system, so there is no need to have equal numbers of sample points on each transect.

At each forage and snow density sampling point, percent cover data and forage species measurements will be taken as explained in Section 3.1.4, except that the sampling point and quadrats will not be marked with stakes. At snow sample points, no cleared and levelled sampling stations will exist, so the snowpack will include shrub branches, other vegetation, and litterfall that may increase the effective depth by holding snow off the ground or keeping it from settling. Slope and aspect will be recorded at each sample point, as will canopy completeness (measured with a moosehorn) and a brief description of stand conditions.

3.3.4.2 Microhabitat sampling

As described above, microhabitat sampling will be applied to deer that use very small areas after selected weather events, especially those that repeatedly bed at the same site. In such cases, we hypothesize that the use of such a small area indicates the presence of especially favourable conditions there, as compared to the surrounding habitat, or that the deer are minimizing energy expenditure because no better habitat is available elsewhere. If the pattern of use indicates particularly favourable snowpack conditions and/or food, the sampling scheme must pick up these features in the locations where the deer was feeding or moving from bed to food, rather

than in scattered locations throughout a heterogeneous habitat type, as is the case in macrohabitat sampling. Activity monitoring is a key feature of the microhabitat sampling approach, because we wish to sample actively feeding deer, and not those that may remain bedded for long periods during harsh weather. Without a record of deer activity to accompany bi-hourly locations, we could not distinguish active from bedded deer.

Microhabitat sampling will be used when 12-24 post-event telemetry locations and the concurrent activity pattern show that a suitable deer is active in a restricted portion of its pre-event range or in a new range entirely, and is moving through an area of approximately 3 ha or less. After bi-hourly locations have been taken and activities monitored for one or two days, locations at which the deer is judged to be feeding or travelling will be plotted on maps and 1:10 000 airphotos. Both the centroid and the error polygon for the radiotelemetry location will be plotted for each of the selected locations. Habitat sampling will then be conducted within a minimum of five of the error polygons, or in five adjacent but non-overlapping portions of the error polygons if there is a high degree of overlap. At least 30 samples of forage abundance and snow density and 120 samples of snow depth will be taken in the post-event range. More samples will be taken if time and stable weather conditions allow. The first 30 forage and density samples and the first 120 snow samples will be placed in the last five radiolocation error polygons where feeding or moving apparently occurred, unless error-polygon overlap from earlier locations, or other factors such as field observations of track density and bedding sites, indicate that the last five polygons are outside the area of most important habitat in the post-event range.

Within each polygon, six forage and density samples and 24 snow samples will be taken on three uphill transects. Transects will run the full uphill width of the polygon (length = t), with snow samples taken at distances from the lower polygon edge of 0.1t, 0.2t, 0.3t, 0.4t, 0.5t, 0.6t, 0.7t, and 0.8t; and forage and density samples taken at distances of 0.4t and 0.8t. Snow and forage samples will be collected as described in the previous section. Slope, aspect, overstory cover, and a brief type description will be recorded at each snow sample point as described in the previous section.

For deer whose post-event ranges are sampled with the microhabitat approach, pre-event ranges could be greatly different in size or location. The sampling approach (macro or micro) to be used for pre-event ranges will be determined by telemetry and the activity pattern of each deer, when available.

3.3.4.3 Advantages and disadvantages of the two approaches

The major disadvantage of the macrohabitat approach is that the scattered distribution of snow and forage samples throughout the heterogeneous habitat types may not coincide with the areas of good snowpack and forage conditions that are sought by deer. We may thus sample too heavily in areas that are not used, and fail to identify the key habitat features. On the other hand, by sampling relatively large patches of habitat in areas where the post-event ranges of several radio-collared deer may overlap, we may be able to use one set of habitat samples to test the preferred habitats of two or more deer.

With the microhabitat method, we will be able to test with greater certainty (time permitting) exactly what habitat conditions one or two deer select after specific weather events. This method is highly dependent on accurate and precise radiolocations and on the ability of field crews to find their way with compass and chain to the true location of error polygons in the field. The quality of radiolocations is related both to the habitat type from which the signal originates (e.g. clearcuts are better than old growth) and to the distance between the transmitter and the receiver, so we will not have the same confidence in detecting small areas of preferred habitat for every monitored deer. We will also be putting a large effort into sampling the weather responses of a small number of deer that may or may not represent the rest of the population. This concern will be evaluated by the comparison of results from the event response tests with the conclusions drawn from the more inferential track count data (Section 3.1) that represent a much larger sample of deer.

3.3.5 Measures and records

All data on snowpack and site features (slope, aspect, overstory cover)

will be recorded on a field sheet designed for direct keypunching (Appendix, p. 76). Measurements of forage plants will be recorded on the same forms used for forage plant measurements on transects (Section 3.1.5).

3.3.6 Planned analyses

Differences between pre-event and post-event ranges will be tested as follows:

1. mean snowpack depth, density, and percent forage cover: t-tests
2. proportions of shallow snowpack depths: G-test or log-linear tests of independence
3. mean forage biomass: t-tests based on biomasses calculated from regressions

3.4 Snow Interception as Influenced by Forest Stand Characteristics

3.4.1 Objectives

This study is designed to investigate the relationship between forest stand characteristics and snow interception. Equations are needed for predicting snow interception in stands of various ages during snow events of various intensities, since snow interception capability is an important factor in prescribing measures for winter habitat management. In addition, this study will briefly examine the patterns of snow accumulation and ablation under immature stands, old-growth timber, and open clearcuts. If time permits, canopy responses to arboreal snow accumulation will also be examined, because this might help to clarify the role of canopy characteristics in the interception of snow. In sampling snow interception, the objective for sample sizes is to estimate sample means that are within 10% of the population means 95% of the time ($p = .10$; $a = .05$).

3.4.2 Variables

The variables to be measured are: 1) fresh snow depth; 2) total snowpack depth; 3) density of the upper 55 cm of the snowpack; 4) stand canopy completeness (defined on p.12); 5) crown length; 6) crown width; 7) height to live crown; 8) tree DBH; and 9) tree height.

3.4.3 Design and layout

Interception is defined as the proportion of a fresh snowfall that accumulates in the forest canopy and that therefore fails to reach the ground. It will be calculated with the following formula:

$$\text{Interception (\%)} = \frac{(Op - Fc)}{Op} \times 100$$

where Op is the measured depth of fresh snow in the open and Fc is the measured depth under a forest canopy.

For application to forest habitat management, snow interception must be related to stand characteristics rather than to individual trees. To understand the canopy-completeness/snow-interception relationship, a range of canopy densities, snowfall intensities (cm depth/hour), and snowfall sizes (total depth of fresh snow) must be sampled.

3.4.3.1 Snowfall requirements

Frequent snow events are essential attributes of the study areas. A range of storm intensities is also important, but sufficient variation in storms is anticipated for any area receiving numerous snowfalls. High-elevation sites would receive the most frequent snowfalls and would also provide a more continuous snowpack, which should aid in the study of snow accumulation and ablation in young forest stands. Unfortunately, examination of candidate high-elevation sites disclosed problems of winter access, stand availability, and stand suitability (based on age, height, and canopy completeness criteria), so that no suitable high-elevation sites (< 1000 m) could be located.

3.4.3.2 Stand selection

For applicability to future forest and wildlife management, the canopy-completeness/snow-interception relationship must be appropriate for young-growth stands. Therefore, young stands (25 to 80 years in age) ranging from 40-90% canopy completeness will be sampled. Only stands greater than 5 ha in area will be used, to minimize the influence of surrounding stands (Shank and Bunnell 1982). Adjacent openings (usually clearcuts) are

needed because they provide the values of Op in the interception equation. To minimize the effects of wind turbulence on falling snow, measurement sites in the openings must be at least seven tree heights from the stand edges. An old-growth site will also be sampled for comparison to young-growth stands with similar canopy completeness. The criteria for size and adjacent opening will apply to it as well.

Potential manpower and winter access limitations make it necessary to locate sites as close together as possible. This will additionally benefit the study by minimizing variations in storm size and temperature.

3.4.3.3 Sampling procedures

Sampling in each of the five stands will involve the collection of canopy, stand, and snow data. The primary study calls for the first two sets of data to be collected only once, with the collection of snow data to be carried out after each snow event. Given the opportunity, canopy completeness measurements will also be taken immediately after each snowfall as part of the second goal of this study. All sampling will be conducted by a two-person crew.

Canopy completeness will be measured with a modified moosehorn (a device that overlays a dot grid on a 10° vertical projection of the forest canopy). Recent work has shown it to be a more precise estimator of canopy completeness than other devices (D.J. Vales, pers. comm.).

Suitable young-growth stands will be chosen based on the criteria of canopy completeness and stand age. Sixty-six sample points will be established in each stand. This sample size has been shown in other studies to meet precision requirements similar to ours (F.L. Bunnell, pers. comm.). Six parallel 10-m lines will be marked with cord strung between trees or stakes. Lines will be about 5 m apart. Eleven sampling points at 1-m intervals will be marked on each line with paint or flagging tape. At each point, canopy completeness will be measured when no snow is on the trees.

In the adjacent openings a similar grid will be laid out and marked. It will only have four 10-m lines instead of six, resulting in 44 sample points.

No canopy completeness measures are needed in the open. None of the sample points in either the forested or open sites will be prepared (i.e. cleared of vegetation, etc.) since the sample sizes used are believed to be adequate for keeping variances low. However, when excessive woody debris (as in spaced stands) or bushy vegetation occurs at snow sampling points, those points will not be used, and the sample lines will be extended so that the desired sample size per line is maintained. Sampling points will be numbered from 1 to 66 with number one being on the left end of the lower or nearest line as the plot is approached from the road, and the last being the left- most sample point on the upper (sixth) line when a zig-zag path across one line and back along the next is followed. Table 4 provides a list of stands that have tentatively been selected for use in this study.

Stand measurements will include species composition, stand age, height, density, and the length and width of tree crowns. For each line, a rectangular plot containing all trees whose canopies extend within 2 m of any sample point will be established. This means that the plot dimensions will be about 15 x 30m, or larger. Standard mensuration techniques will be used to obtain the required data, except for crown width, which will be determined as the geometric mean of the minimum and maximum cross-sectional dimensions of the tree crown. Stem-mapping will be undertaken if time permits.

After a snow event, and before changes in the snowpack occur through melt or settling, all sites will be visited and snow measurements taken. At each of the sample points in each site, the depth of fresh snow will be measured and recorded to the nearest centimetre. The separation between fresh snow and the rest of the snowpack is usually apparent due to crusting or compaction of the older snow, so few problems are anticipated in determining fresh snow depth. Total snowpack depth will also be measured at each sample point. Measurements of the density of the upper 55 cm of the snowpack will be taken at every third point using a Stevenson snow tube. On those occasions where snow and weather conditions remain stable long enough, canopy measurements will also be taken while the snow is still in the tree canopies. Comments on general snow and weather conditions will be recorded

TABLE 4 Features of stands selected for snow interception sampling

Area	Stand description	Mean canopy completeness (%)	Stand age	Approximate elevation (m)	Slope (%)	Adjacent opening designation
Nanaimo River	Old growth	90	mature	720	50	1
	Old growth	60	mature	400	flat	2
	Unthinned young growth	80	28	400	flat	2
	Tall backlog spacing and pruning	70	40	350	10	3
	Short backlog spacing and pruning	40	40	350	10	3
Sayward Forest	Old growth	60	mature	180	flat	4
	Unthinned young growth	80	40 +	180	flat	4
	Commercially thinned (1983)	40	40 +	180	flat	4
	Unthinned young growth	75	40	180	flat	4
	Backlog spaced (1981)	50	40	180	flat	4
Woss*	Old growth	not available at present				
	Unthinned young growth		60			
	Thinned and pruned young growth		60			

* To be sampled by Canadian Forest Products Limited.

with each sample.

3.4.4 Measures and records

Three types of data forms will be used during fieldwork. Stand, canopy, and snow data will be recorded on separate forms. Stand information will be recorded on a modified version (p. 79) of the Resource Analysis Branch mensuration form (Walsmley et al. 1980, p.151). Data forms for canopy completeness estimates and snow measurements are shown on pages 78 and 77 respectively. All field sheets will be printed on waterproof paper.

3.4.5 Planned analyses

The data collected in this study will be used to: 1) examine the relationships between canopy completeness, snow interception, and storm size; 2) explore the importance of live crown width and length in the canopy/snow equation; 3) determine the change in canopy completeness caused by snow accumulating in the canopy; and 4) investigate differences in snowpack accumulation and ablation among stands of different mean canopy completeness.

3.4.5.1 Snow interception

Regression analysis will be employed to develop predictive equations, with mean canopy completeness as the independent variable and interception as the dependent variable. Regressions will be calculated separately for all sets of snow data (individual snowfalls and stands). Data will be pooled if regressions are not significantly different, resulting in regressions for all stands stratified by storm size (combining data from all stands), and for all storm sizes stratified by stand type (combining data from all storms). If interception curves are significantly different between snowfalls, fresh snow depth (our measure of storm size) will be used as a second independent variable to develop the predictive equation for snow interception. The multiple regression equation will have the following form:

$$\text{Interception} = f(\text{canopy completeness} + \text{storm size})$$

Stand averages could be graphically presented as a three-dimensional response surface from which interception predictions could be made.

3.4.5.2 The role of crown structure in interception

The value of adding crown length and width to the snow interception regression will be explored with multiple regression. An index of crown surface area (CI) will be calculated by the multiplication of crown width by crown length for each tree, as suggested by Bunnell et al. (1984, p.304), and will be added to the regression equation:

Interception = f(canopy completeness + storm size + CI).

The contribution of these components of crown area to the predictive value of the equation will be determined through the use of stepwise regression analysis on the plot means of interception, canopy completeness, storm size, and CI. This approach is necessary due to the plot size for tree samples.

3.4.5.3 Canopy response to arboreal snow accumulation

If weather conditions allow post-storm canopy values to be sampled, the following analyses will be undertaken: 1) regressions of post-snowfall canopy completeness versus no-snow canopy completeness values for different stands and storms; and 2) similar regressions with pooled samples. The results obtained here may help to explain the results of Sections 3.4.5.1 and 3.4.5.2 and could be the basis for deciding on the validity of combining data from separate storms or stands.

3.4.5.4 Differences in snowpack accumulation and ablation

Differences among stands in total snowpack depths will be assessed with the use of ANOVA for mean depth and G-tests of independence for frequency distributions of depth (Sokal and Rohlf 1981). The results, combined with interception data, should help to explain snow-stand relationships through the accumulation and ablation phases of the winter.

4 SAMPLING SCHEDULE AND AREA PRIORITIES

The activities described in Sections 3.1, 3.3, and 3.4 are mutually exclusive because available staff and vehicles allow only one type of sampling to be carried out at a time. In choosing which approach to use at a given time, a number of factors must be weighed, including the priority of the research question to be investigated, the number of previous samples acquired, and the type of weather event occurring.

A decision key to be used in the selection among alternative activities as the winter progresses is reproduced in the Appendix (p. 80). Because changing weather conditions, deer movements, and habitat type differences will affect our choice of the area (Dunsmuir Creek or Jump Creek) to be sampled on any given occasion, the relevant features of the two watersheds are summarized in Table 5.

TABLE 5 Characteristics of Jump Creek and Dunsmuir Creek study areas

Feature	Jump Creek	Dunsmuir Creek
Old-growth stand	High quality, traditional winter range with smaller trees and relatively good understory, good lichen litter and numerous rock bluffs	Poor quality winter range with larger trees; historically not used heavily until other old growth adjacent was logged; deer use is heavy now, but the understory is sparse and still recovering from heavy browsing during 1981/82 winter. Lichen litter good, but few rock bluffs
Young-growth stands	About 20 years old throughout area	Range of ages from 13 to 28 years and more variable than in Jump Creek
Snowpack	Elevation 450-850m; aspect south, so snow is less common; snowpacks usually shallower and of shorter duration than Dunsmuir Creek	Elevation 600-920m; aspect southwest, so snow is more common; snowpack usually deeper and longer lasting than in Jump Creek
Access	Good	Roads in poor condition relative to Jump Creek
Deer	Majority of deer with radio collars in close proximity to winter range and will probably use it during deep snow	Deer with radio collars spread across hillside; hard to predict if animals will use Dunsmuir winter range and if so, which ones will be there; a greater likelihood of a radio-collared deer attempting to winter in second growth here

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6 APPENDIX

Data recording forms and other materials for field activities can be found in this section:

6.1 Transect Location Descriptions and Maps 50
(Section 3.1)

6.2 Data Forms for Snow, Track, and Forage Cover Estimates 65
(Section 3.1)

6.3 Data Form for Radiotelemetry Locations 67
(Section 3.2)

6.4 Detailed Instructions for Forage Plant Measurements 68
(Section 3.1)

6.5 Data Forms for Forage Plant Measurements 74
(Section 3.1)

6.6 Data Form for Snow Characteristics during Event Response Tests (Section 3.3) 76

6.7 Data Forms for Snow Interception, Canopy Completeness, and Stand Characteristics (Section 3.4) 77

6.8 Decision Key for Selecting Area Priorities and Scheduling Activities 80

NANAIMO RIVER SNOW / TRACK TRANSECT LAYOUT.

All of the snow stations and accompanying track count segments are designated by a three part code: area-habitat-station. The following is a key to each part.

Area 1 = Dunsmuir Creek; Area 2 = Jump Creek

Habitat 1 = mature timber and includes stations 1 through 30.
Habitat 2 = slash It includes stations 31 through 60.
Habitat 3 = unspaced young growth. It includes stations 61 through 90.
Habitat 4 = spaced young growth. It includes stations 91 through 120.

Transect Layout

All transects run uphill or downhill. They are marked with pink flagging, although dots of blue paint also indicate the lines in some cases. Transect beginnings and ends are indicated by stakes with blue and yellow paint on them. All stakes in between have only yellow paint on them.* Blank tags of blue plastic are stapled to 'start' stakes. All other stakes have a numbered tag on them whose number corresponds to the station number. Starting stakes have no accompanying snow board and no snow or forage measurements are taken there. Only yellow stakes or end stakes with station numbers have snow boards. Due to tag loss problems, trees adjacent to the station stake may be painted with the station number.

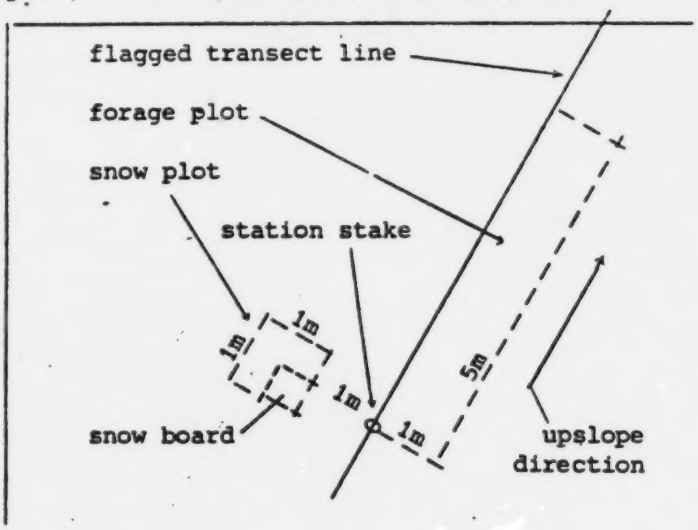
Blue-and-yellow bulls-eyes (often with painted transect numbers) mark the places where transects intersect main roads. Where transects are connected within a habitat type, flagging and paint mark the route.

On the transect maps, the dotted end of the transect represents the start (which has a yellow and blue stake with a blank tag) of the 50m track count segment. Dashes and numbers represent the snow measurement stations and the ends of the track count segments. Tracks counted from a starting stake to a numbered station are assigned to the numbered station. Tracks counted between consecutively numbered stations are recorded as belonging to the interval of the station with the larger number, regardless whether the transect runs upslope or downslope.

Station Layout

Each station consists of a painted, tagged stake and a cleared snow plot with a snowboard. The snow plot, as shown, is a 1m. x 1m. area of cleared and smoothed ground. It is located one meter to the left of the stake (as viewed when facing uphill). The 0.5 x 0.5 meter snow board is positioned in the lower righthand corner of the snow plot.

A forage sampling plot is also present but is unmarked. The station stake is the lower lefthand corner of this plot. The plot is 1 meter wide and 5 meters long, running uphill along the transect line. For measurement purposes, the forage plot is actually a rectangular cube which extends 150 centimeters above the ground or snow surface.



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* except station 107 of transect 1-4-2 (see description).

NANAIMO RIVER WINTER SNOW / TRACK TRANSECT DATA COLLECTION PROCEDURE.

The following is a description of the data sheet and how to complete it.

DIAGRAM: Circle the number that corresponds to the number of times that the transects will have been run upon completion of this session. Ie., is this the first, second, ... run?

BOXES 6 through 15: self-explanatory.

BOXES 16 through 19: Number of hours since the end of the snowstorm.

BOXES 20 through 25: Insert the initials of the crew collecting the data.

BOXES 26 through 31: Complete from the transect descriptions and maps. Check against the station tag.

BOXES 32 and 33: Enter the number of fresh sets of deer tracks that crossed the transect between stakes.

BOX 34: Fill in with the number of crossings (between the stakes) at which it was not possible to distinguish between sets of deer tracks.

BOXES 35 through 37: Measured to the nearest centimeter in the same portion of the plot as is indicated by the circled number in the diagram.

BOXES 38 and 39: The depth of fresh snow on the snow board is measured to the nearest centimeter. Clean off the board when finished.

BOXES 40 and 41: The depth to which the snow penetration gauge sinks when a pressure of 1900gm/cm^2 is applied (measured to the nearest centimeter). The measurement is taken in the same area of the plot as is indicated in the diagram <u>but</u> not on the same spot as the snow depth was measured.

BOXES 42 and 43: The depth to which one of the crew sinks when all of their weight is transferred to one foot is recorded as the Booted foot sinking depth. It is measured to the nearest centimeter and should be taken in the vicinity of the snow plot but not in it.

BOXES 44 and 45: Insert the initials of the crew member who does the booted foot sinking depth. This person should do the B.F.S.D. at all stations to maintain consistency.

BOXES 46 through 48: Completed using the choices listed on the bottom of the data sheet.

BOXES 49 through 80: Add any applicable notes on snow or tracks.

<u>Note</u>: Avoid walking on the snow plot or on the vegetation plot areas when sampling the snow at the stations. Between stations try to walk in single file to reduce the snow disturbance.

Dunsmuir Creek

Habitat 1 (mature timber)

Transect 1 (1-1-1) is reached by following transect 1-3-1. The bearing is 30° and follows a pellet transect. It includes stations 1 to 9.

Transect 2 (1-1-2) is reached by following tr. 1-3-2. The bearing is 30° and follows a pellet transect. It includes stn. 13 to 21.

Transect 3 (1-1-3) is reached from tr. 1-1-2 by following a line of blue dots on trees. The transect bearing is 210°. It includes stn. 22 to 30.

Transect 4 (1-1-4) is reached by following a line of blue dots from stn. 5 of transect 1-1-1. The transect follows a bearing of 210° and includes stations 10 to 12.

Habitat 2 (slash)

Transect 1 (1-2-1) begins about 100m from the timber on D-11D. The starting point is 25m below the road. The transect follows a bearing of 45° and includes stations 31 to 39. Stn. 37 is on the lower edge of T-4B. Stn. 39 is at a bearing of 90° from stn. 38.

Transect 2 (1-2-2) is reached from the top of tr.1-2-1. It follows a bearing of 225° and includes stations 40 to 47. Stn. 41 is on the upper edge of T-4B and stn. 47 is on the lower edge of D-11D.

Transect 3 (1-2-3) starts 50m below D-11D and follows a bearing of 45°. It includes stations 48 to 58. Stn. 48 is on the lower edge of D-11D and stn. 54 is just above T-4B.

Transect 4 (1-2-4) is reached from stn. 57 of transect 1-2-3, follows a bearing of 225° and includes stations 59 and 60.

Habitat 3 (unspaced young growth)

Transect 1 (1-3-1) follows a bearing of 30° and includes stations 61 to 67. Station 62 is 25m below J-3.

Transect 2 (1-3-2) follows a bearing of 30° and includes stations 75 to 83. Station 78 is on the lower edge of J-3.

Transect 3 (1-3-3) is reached from the end of transect 1-1-3. The transect bearing is 210° and the transect includes stations 84 to 90.

Transect 4 (1-3-4) is reached from the end of transect 1-1-4. The transect bearing is 210° and the transect includes stations 68 to 74. Stn. 72 is 30m below J-3.

Habitat 4 (spaced young growth)

Transect 1 (1-4-1) follows a bearing of 40° and includes stations 91 to 100. Station 91 is 25m below J-3. The transect follows a pellet transect.

Transect 2 (1-4-2) begins about 450m east of transect 1-4-1. The transect follows a bearing of 220° and includes stations 101 to 110. Stn.107 has a blue-topped stake to indicate the end of the track count segment, and another stake 6m further downhill for snow measurements. Station 108 is on the upper edge of J-3. The transect is on a pellet transect.

Transect 3 (1-4-3) begins below J-3 and follows a bearing of 40°. It includes stations 111 to 120. Station 113 is just below J-3. Station 120 is 30m below the start of transect 1-2-3.

Jump Creek

Habitat 1 (mature timber)

Transect 1 (2-1-1) begins 250m east of transect 2-1-4 on J-11. It includes stations 4 to 12 on a bearing of 348°. The bearing changes to 338° at station 10. The start is 20m above J-11.

Transect 2 (2-1-2) is reached from the top of transect 2-1-1. It follows a 168° bearing and includes stations 13 to 21. The start is near J-7 and stn. 21 is 20m above the marked tree on J-11. It follows a pellet transect.

Transect 3 (2-1-3) is reached by continuing past the end of transect 2-4-4 (located 250m up J-11 from J-11A) on a 348° bearing. The start is 150m from J-11. The transect follows a pellet transect and includes stations 22 to 30. Station 23 is on J-7C, with the snowboard placed 2m out from the painted tree on the lower edge of the road. The next 50 meters is not a track count segment, but the stake for the beginning of the 24th interval is at the end of it. The rest of the transect is 'normal', with station 30 found just short of J-7.

Transect 4 (2-1-4) begins 15m from the painted tree above J-11 near the western edge of the mature timber stand. The transect includes stations 1 to 3 and follows a 348° bearing.

Habitat 2 (slash)

Transect 1 (2-2-1) is the transect farthest from the Jump Creek winter range. It follows a bearing of 175° and includes stations 31 to 39. Station 34 is on the center of J-11. There is no stake, but the snow board is located 3m out from the painted rock on the upper road edge.

Transect 2 (2-2-2) is reached from station 39 of trans. 2-2-1. It includes stations 40 to 48 on a 335° bearing. Station 43 is located 10m below the bottom edge of J-11. There is a bearing change to 325° at station 47.

Transect 3 (2-2-3) is reached from stn. 48 of trans. 2-2-2. It follows a 145° bearing and incorporates stations 49 to 57. Station 55 is found 25m below the lower edge of J-11.

Transect 4 (2-2-4) is reached from station 57, and includes stations 58 to 60. The bearing is 335° and station 60 is on the lower edge of J-11.

Habitat 3 (unspaced young growth)

Transect 1 (2-3-1) is the most westerly transect in this type. Bearing 160°, it includes stations 61 to 63. Station 63 is 15m above J-11A.

Habitat 3 cont.

Transect 2 (2-3-2) is 50m east of transect 2-3-1 on J-11A and follows a 340° bearing. It includes stations 64 to 66, with the start 10m above the road.

Transect 3 (2-3-3) is reached from the top of transect 2-3-2. It follows a bearing of 160° with three stations (67 to 69), the last of which is located 20m above J-11A.

Transect 4 (2-3-4) is 50m east of trans. 2-3-3. It has three stations (70 to 72) on a 340° bearing. The start is 10m above J-11A.

Transect 5 (2-3-5) is reached from stn. 72 of trans. 2-3-4. It follows a 160° bearing and has three stations (73 to 75), of which stn. 75 is 25m above J-11A.

Transect 6 (2-3-6) begins on J-11A, 50m east of trans. 2-3-5 (a log marks the spot). It follows a 340° bearing, ending at a mature tree on the extreme s.w. corner of the mature timber patch. The starting stake is 30m above J-11A. There are only two stations, 76 and 77, with the latter found 25m below the tree.

Transect 7 (2-3-7) is reached from the tree at the top of transect 2-3-6 (50m at 90°, then 10m @ 160°). It has a bearing of 160° and includes stations 78 to 80, with stn. 80 found on the lower edge of J-11A.

Transect 8 (2-3-8) begins 50m east of stn. 80 of trans. 2-3-7 (a painted tree on the upper edge of J-11A is the start) and follows a bearing of 340°. There are three stations (81 to 83).

Transect 9 (2-3-9) is reached from stn. 83 of trans. 2-3-8 and includes stations 84 to 86 on a 160° bearing. Station 86 is located 20m above the middle of J-11A.

Transect 10 (2-3-10) is located 50m east of trans. 2-3-9 and follows a 340° bearing. It includes stations 87 to 90, with a painted seedling on the upper edge of J-11A acting as the start. From stn. 89 the next stake (which is the start of the 90th interval) is found 25m away on a 250° bearing. The bearing to station 90 then changes to 160°. Transect 2-3-10 is located just west of the major washout on J-11A.

Habitat 4 (spaced young growth)

Transect 1 (2-4-1) starts on J-Main about 900m west of J-11. Following a pellet transect (bearing 348°), this line has seven stations (91 to 97). The start is 15m above the edge of J-Main, with stn. 94 found 15m above J-11A and stn. 97 located on the edge of the mature timber.

Transect 2 (2-4-2) starts about 125m east of the top of trans. 2-4-1 on a 168° bearing. It has six stations (98 to 103), with the start 50m below J-11, station 101 found 10m below J-11A and stn. 103 30m above J-Main.

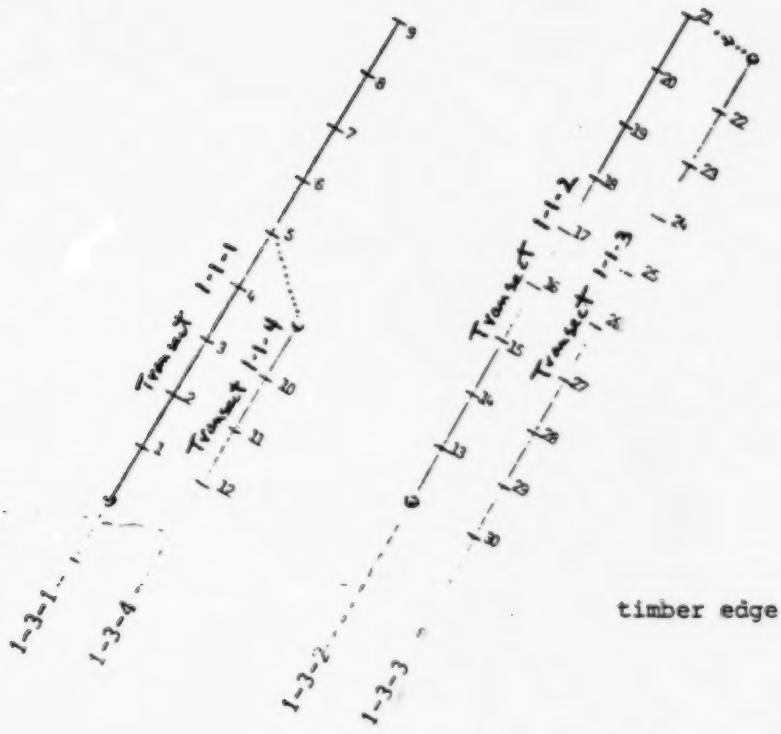
Habitat 4 cont.

Transect 3 (2-4-3) is 100m east of trans. 2-4-2, and has six stations (104 to 109) on a 348° bearing. The starting stake is on the upper edge of J-Main, with station 106 located 5m below J-11A and station 109 found 25m below J-11.

Transect 4 (2-4-4) follows a pellet transect and is 125m east of trans. 2-4-3 on J-Main. It follows a bearing of 348° and has eight stations (110 to 117), with the starting stake located 40m below the painted tree that is on the upper edge of J-Main. Station 110 is 15m above the road edge. The snow board for station 111 is on a stump. Station 113 is 2m below the lower edge of J-11A, with station 115 found on the lower edge of J-11.

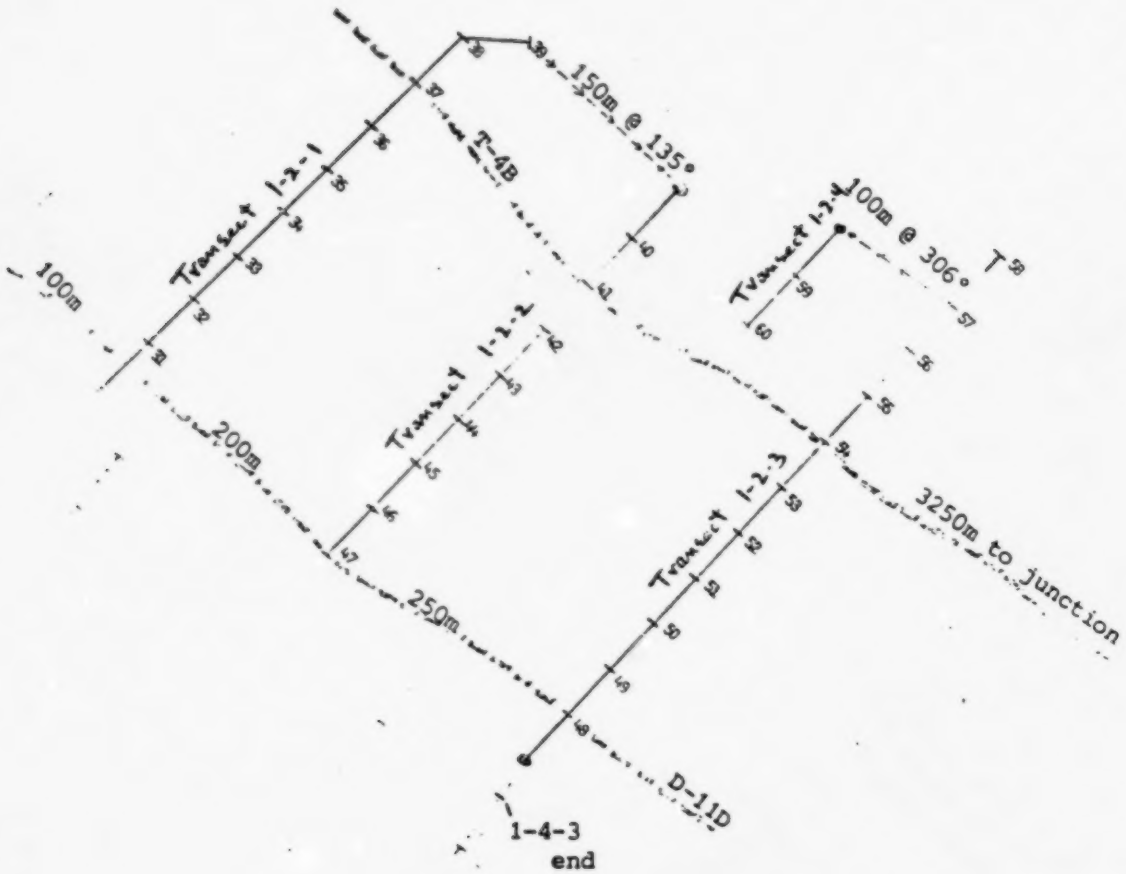
Transect 5 (2-4-5) begins at the J-11/J-11A junction. It follows a 348° bearing and includes stations 118 to 120. The starting stake is 25m from the center of the road junction.

Dunsmuir Creek Mature Timber area 1, stations 1 to 30.

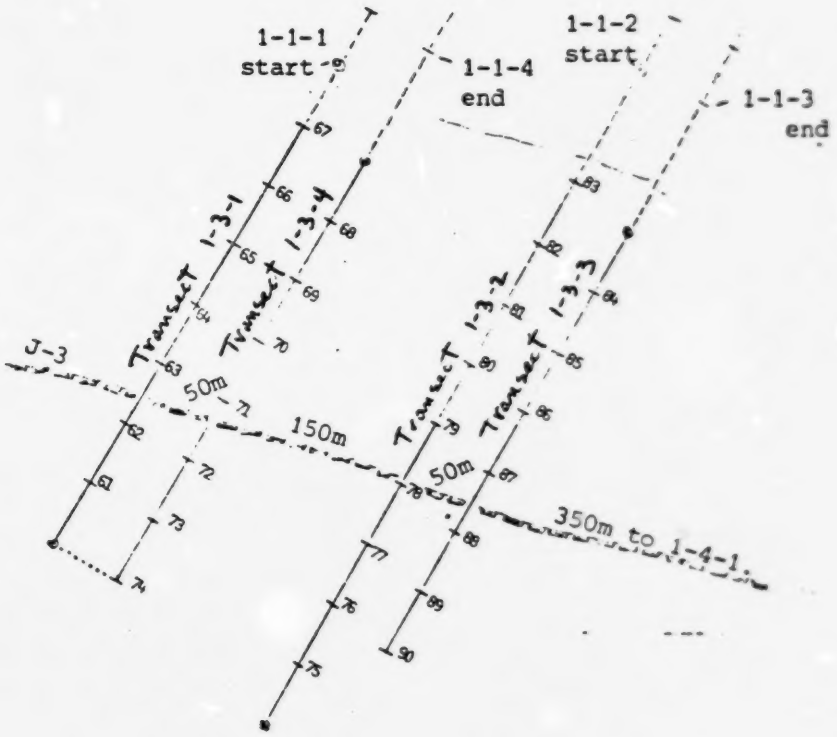


timber edge

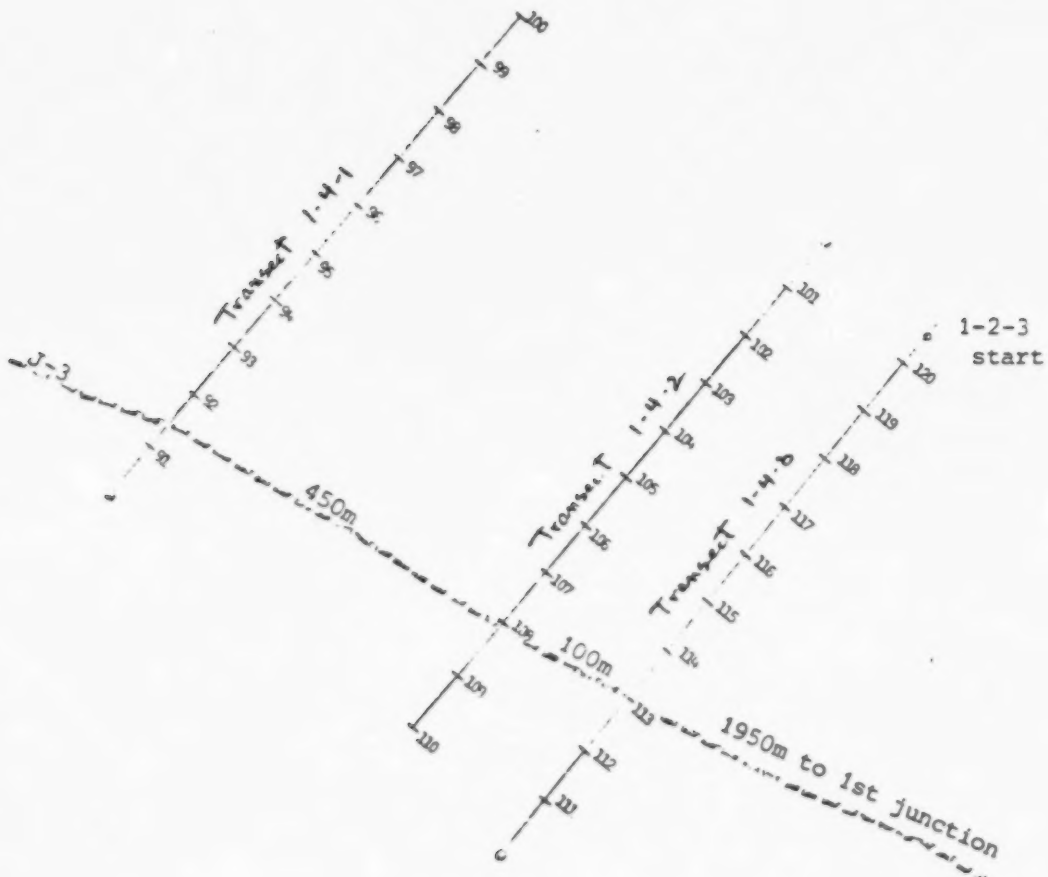
Dunsmuir Creek Slash area 1, stations 31 to 60.



Dunsmuir Creek Unspaced Young Growth area 1, stations 61 to 90.

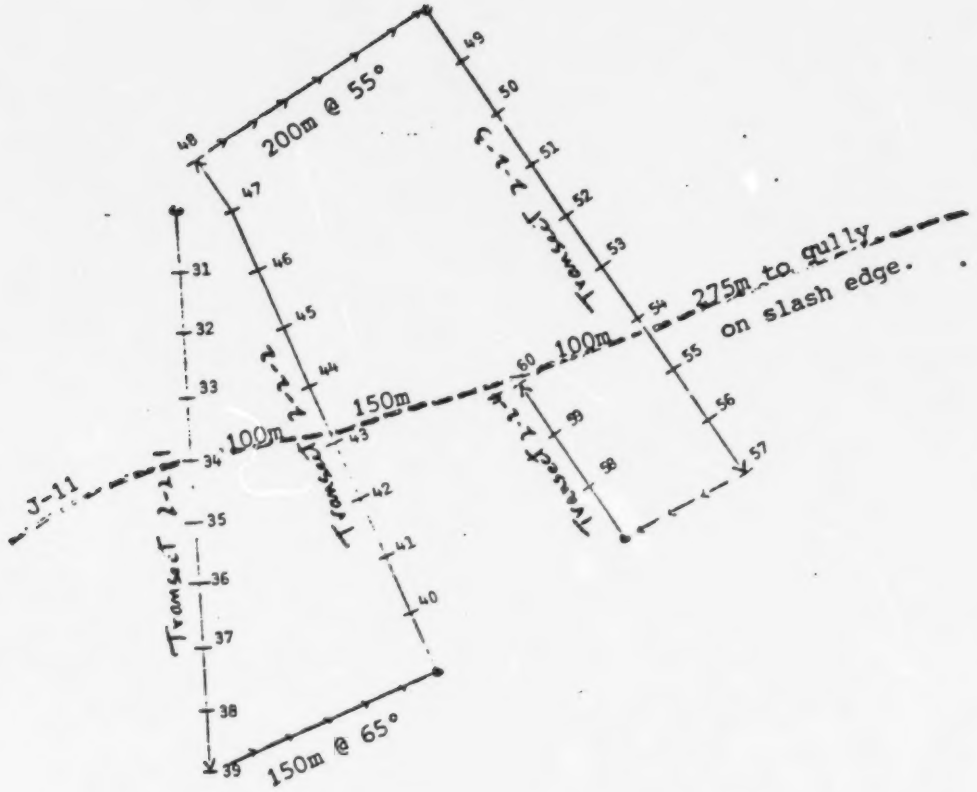


Dunsmuir Creek Spaced Young Growth area 1, stations 91 to 120.

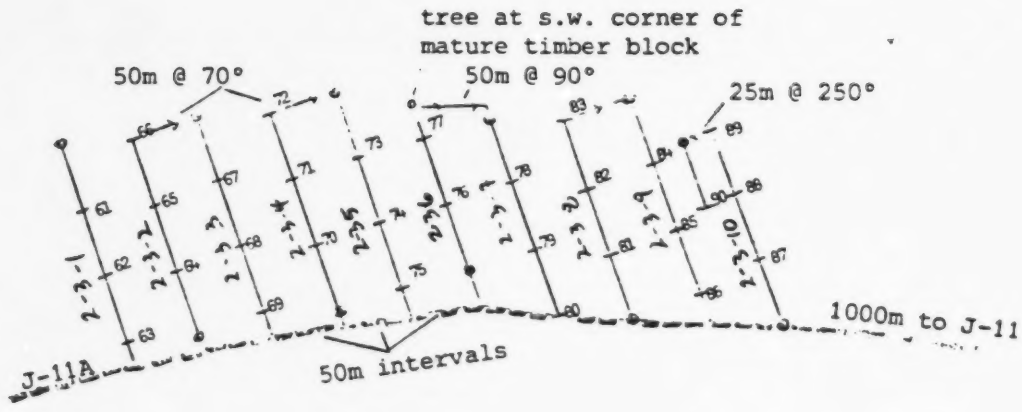


Jump Creek Mature Timber area 2, stations 1 to 30.

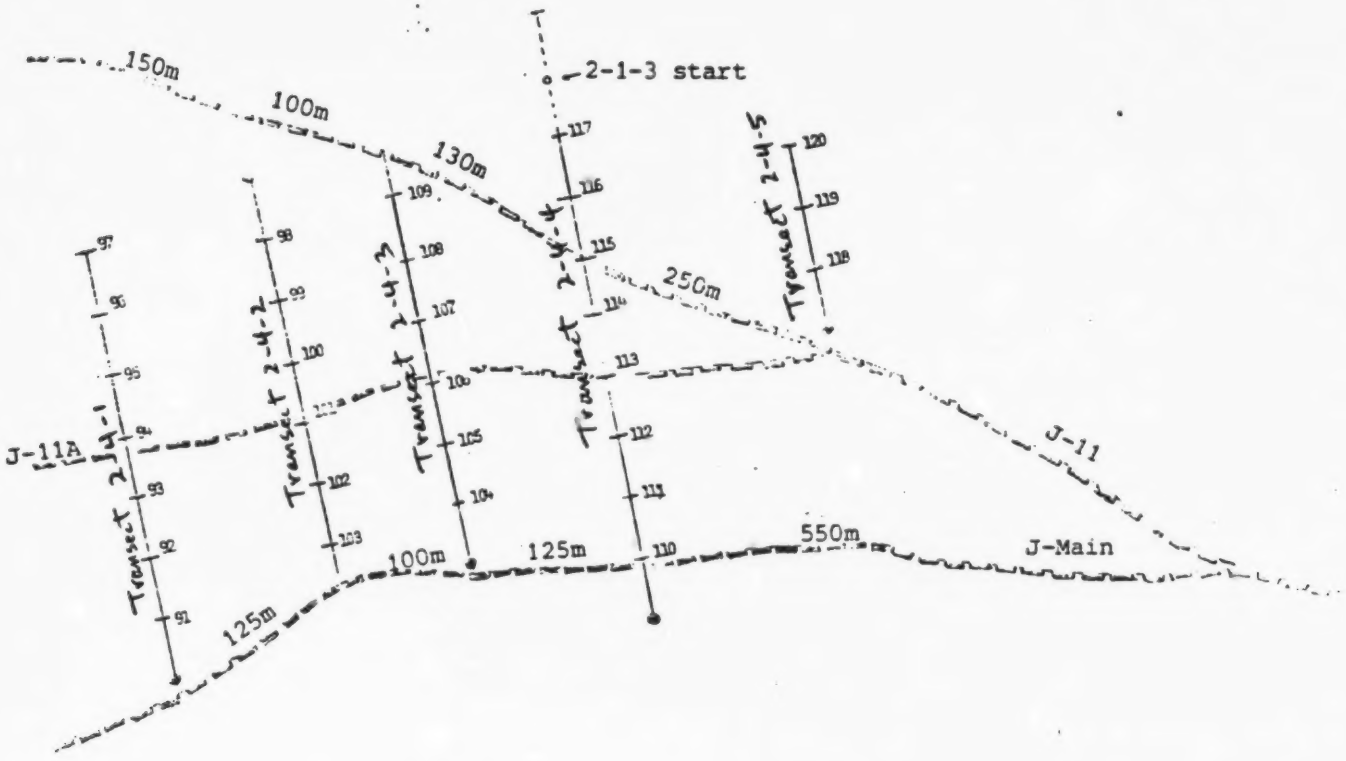
Jump Creek Slash area 2, stations 31 to 60.



Jump Creek Unspaced Young Growth area 2, stations 61 to 90.



Jump Creek Spaced Young Growth area 2, stations 91 to 120.



NANAIMO RIVER WINTER SNOW / TRACK TRANSECTS

E P 9 3 4 0 2 Date (YY/MM/DD): Time:

Time since last snowfall (hrs): Area: Station:

Track counts Number of sets of tracks: Number of trails:

Snow depth At 25m: Total (cm.): Fresh (cm.):

At station: Total (cm.): Fresh (cm.):

Snow age: Snow condition:

Snow density tube Outside depth: Inside depth:

Empty tube wt.: Total wt.: Core problem:

Comments

E P 9 3 4 0 2 Date (YY/MM/DD): Time:

Time since last snowfall (hrs): Area: Station:

Track counts Number of sets of tracks: Number of trails:

Snow depth At 25m: Total (cm.): Fresh (cm.):

At station: Total (cm.): Fresh (cm.):

Snow age: Snow condition:

Snow density tube Outside depth: Inside depth:

Empty tube wt.: Total wt.: Core problem:

Comments

Snow age categories: (1) fresh; (2) old

Snow condition categories:
(1) powder (4) granular
(2) sticky (5) uncrusted
(3) slushy (6) crusted

Core problems (when INSIDE depth < 80% OUTSIDE depth):

(1) crusting (4) shrubs
(2) air pocket (5) unknown
(3) compaction

NANAIMO RIVER WINTER FORAGE ASSESSMENT: (1) PERCENT COVER

EP93402 Date (YY/MM/DD): Area: Station:

Species: %: Species: %:
Species: %: Species: %:
Species: %: Species: %:

EP93402 Date (YY/MM/DD): Area: Station:

Species: %: Species: %:
Species: %: Species: %:
Species: %: Species: %:

EP93402 Date (YY/MM/DD): Area: Station:

Species: %: Species: %:
Species: %: Species: %:
Species: %: Species: %:

EP93402 Date (YY/MM/DD): Area: Station:

Species: %: Species: %:
Species: %: Species: %:
Species: %: Species: %:

EP93402 Date (YY/MM/DD): Area: Station:

Species: %: Species: %:
Species: %: Species: %:
Species: %: Species: %:

EP93402 Date (YY/MM/DD): Area: Station:

Species: %: Species: %:
Species: %: Species: %:
Species: %: Species: %:

DEER RADIOLOCATION FORM

Page ___ of ___

DATE: _____ INVESTIGATOR(s) _____

ANTENNA: _____

	1	2	3	4
TEMP. (code)				
CLOUD (code)				
WIND (code)				
PRECIP. (code)				
SNOW (code)				

LOCATION	FREQ.	TIME	BEAR.	G/F/P ACC.	ACT./ INACT.	S/M/W SIG. STR.	COMMENTS

NANAIMO RIVER FORAGE SAMPLING
FIELD CREW INSRUCTIONS

TRANSECT SAMPLING

Sampling Sites

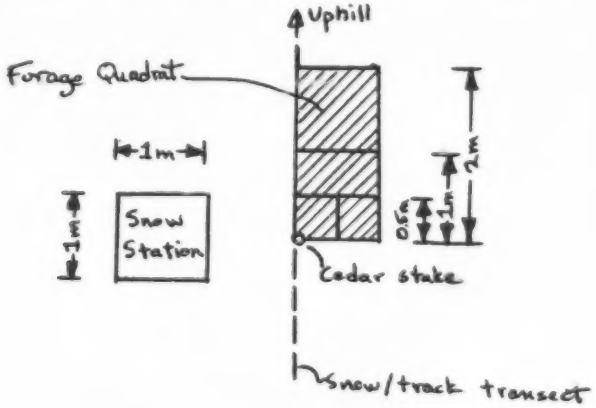
There are 30 sampling stations per habitat type. Four types will be sampled in Jump Creek and four in Dunsmuir Creek: old growth, clearcut, spaced immature, and unspaced immature. The sampling stations are marked with yellow-topped cedar stakes placed 50 m apart (slope distance) on transects running uphill through each type. Each yellow stake originally carried a blue tag with the number of the sampling station, but some tags have been lost. On the attached sheets are illustrations of the general layout of transects in both study areas and also detailed diagrams and descriptions of the locations of transects and sampling stations.

Sampling Procedure

Two crews will be sampling snow, deer tracks, understory, and percent cover while two other crews sample forage abundance.

Access will be by truck or snowmobile. Transects within a type can be sampled in any order. The places where transects cross roads are marked with yellow and blue bulls-eyes painted on trees, stumps, or rocks. Each crew must attempt to complete 60 stations per crew per day.

At each sampling station, the layout is as sketched below:



At each station, sample one 2-m^2 quadrat. This quadrat is to be located with its left edge lying along the transect line, and its lower left corner at the stake.

When sampling at each station, be careful to walk between the stake and the snow plot, or on the east (right) side of the forage quadrat, so as not to disturb the snow that we will be measuring. Also, disturbance inside the quadrats must be kept to a minimum.

Data are to be recorded separately for each quadrat on the forms provided. Sample only deer forage plants listed on the attached sheet, or any other species encountered on the quadrats that shows obvious signs of browsing. The 7-letter codes for species - rather than their full Latin names - are to be entered on the data form.

Record only plants that are rooted inside the quadrat, not those that overhang it. Only live plants are to be measured and recorded, but remember that if any part of the plant is alive it must be sampled.

Five categories of forage will be sampled:

1. Rooted conifers less than 1.5 m tall (above snow surface): Douglas-fir, western hemlock, western redcedar, western yew.
2. Conifer litterfall with green foliage inside the quadrat.
3. Arboreal forage lichen within 1.5 m of snow surface: green and brown beard lichen, primarily Alectoria Sarmentosa, but Bryoria and Usnea spp. also if they are present.
4. Shrubs: majority will be salal and red huckleberry.
5. Ferns: sword fern and deer fern.

The majority of data will be recorded on the forms titled MEASUREMENTS (p. 74). For each live stem of a shrub, fern, or conifer that emerges from the ground or snow within the quadrat, record the species name and a size measurement. For shrubs and conifers, use the dial calipers to measure the smallest diameter of the stem where it emerges from the ground or snow (but above the point of any basal swelling). Record this value to the nearest

10th of a millimetre. For ferns, measure the length of each frond above the ground or snow using the carpenter's tape, and record it in centimetres. For lichen litterfall, record an estimate of percent ground or snow cover. This value will be 0, 1%, 5%, or the multiple of 5% that is closest to the estimate of the true percent cover, up to a maximum of 99%. On this form as on all others, be sure to record observer's initials, the date of sampling, the area code ("D" for Dunsmuir Creek or "J" for Jump Creek), station number, and any pertinent notes. Even if there is no forage on a quadrat, fill in the date, area, and station, and put a horizontal line through unused spaces on all forms.

When a species is densely and uniformly distributed over the whole 2-m^2 area or more, and measurement of all individuals would be too time-consuming, the quadrat size will be reduced to either 0.25 m^2, 0.5 m^2, or 1 m^2, whichever is large enough to include a minimum of 10 measurements. The 0.25-m^2 quadrat will cover the lower left (southwest) corner of the 2-m^2 quadrat; the 0.5-m^2 quadrat will cover the lower (south) edge of the 2-m^2 quadrat; and the 1-m^2 quadrat will cover the lower half of the 2-m^2 quadrat. Note that the quadrat size must be recorded and that one form allows recording of up to 18 stems per quadrat. More than one form may be used for a quadrat.

The alternate form is titled BROWSE (p. 75). It is to be used for all occurrences of red huckleberry, or when a heavily browsed shrub of another species is encountered having a "broomed" mass of short stems and twigs at its top, just sticking out of the snow. For all red huckleberries, the smallest diameter is to be recorded as for other shrubs, but the length of the plant from the diameter measurement point to the end of the longest branch is also to be taken. However, for heavily broomed huckleberries or other species, a single plant could have 20 or more small twigs emerging from the snow surface and the sampling time to measure all of them would be very great. To simplify matters in that case, count the number of stems

emerging, measure the length of the longest one (cm) and then dig down in the snow to the nearest point that allows you to measure the smallest diameter of the main stem. This is the only case where you should disturb the snow surface. After taking the stem diameter, smooth the snow back to its original level, or as close as possible. On the Browse form, there is a space for recording four individuals of a species on one form. For red huckleberries (VACCPAR), the spaces for "Twigs" and "Max. L. (length)" will be left blank if the snow surface does not intersect the broomed portion of the plant.

Exceptions

The sampling procedure as described above will be modified in exceptional cases:

1. If more than 50% of the area of a quadrat is occupied by the bole of a large tree, a bare rock, fresh woody debris, or other substrate unsuitable for plants, move the quadrat uphill or downhill to avoid it, but stay within the large percent cover plot (1 x 5 m) and make a note of the change on the plot form.
2. If a plant is dead or is bent over by snow so all or most of the leaves or small twigs are buried, don't sample it.
3. If all leaves of a live salal stem have been buried or eaten, don't sample it.
4. If a conifer branch has fallen across the quadrat, but all the green foliage is outside the quadrat, don't sample it.
5. If a rooted conifer that is taller than 1.5 m is in the quadrat, don't sample it.
6. If salal or other plants are so thick that you can't get the quadrat frame down to the ground or snow surface, look down vertically on the edges of the frame to gauge which stems are in and which are out.

EVENT RESPONSE SAMPLING

In addition to the three samples of the snow and track transects, we also plan to evaluate the responses of specific radio-collared deer to major weather events such as heavy snowfalls on at least three occasions. In these "event response" tests, we will be sampling two areas for each deer after the event has occurred; these will be the area it occupied immediately before the event and the area it occupies after the event. There will be no permanently marked transects in these areas. Depending on deer movements, sampling may cover areas that vary considerably in size, but the data to be collected and the sampling methods will remain as for the snow/track transect sampling.

LIST OF DEER FORAGE SPECIES AND CODES

Latin name	Common name	Code
	(A) Rooted conifers 2 m tall	
Pseudotsuga menziesii	Douglas-fir	PSEUMEN
Taxus brevifolia	Western yew	TAXUBRE
Thuja plicata	Western redcedar	THUJPLI
Tsuga heterophylla	Western hemlock	TSUGHET
	(B) Conifer litterfall	
Pseudotsuga menziesii		PSEULIT
Taxus brevifolia		TAXULIT
Thuja plicata		THUJLIT
Tsuga heterophylla		TSUGLIT
	(C) Shrubs	
Amelanchier alnifolia	Saskatoon	AMELALN
Cytisus scoparius	Scotch broom	CYTISCO
Gaultheria shallon	Salal	GAULSHA
Mahonia nervosa	Oregon grape	MAHONER
Paxistima myrsinites	Oregon boxwood	PAXIMYR
Prunus emarginata	Bitter cherry	PRUNEMA
Ribes sanguineum	Red-flowering currant	RIBESAN
Rosa sp.	Wild Rose	ROSA
Rubvus leucxodermis	Black raspberry	RUBULEU
Rubus parviflorus	Thimbleberry	RUBUPAR
Rubus spectabilis	Salmonberry	RUBUSPEC
Vaccinium parvifolium	Red huckleberry	VACCPAR
Vaccinium Alaskaense and V. ovalifolium	Blueberries	VACCINI
	(D) Ferns	
Blechnum spicant	Deer fern	BLECSPI
Polystichum munitum	Sword fern	POLYMUN
	(E) Lichens	
Alectoria spp., Bryoria spp., Usnea spp.		LICHLIT

NANAIMO RIVER WINTER FORAGE ASSESSMENT: (2) MEASUREMENTS

EP9340 2 Date (YY/MM/DD): Area: Station:

Quad. size: Species: Meas.:

Date (YY/MM/DD): Area: Station:

Quad. size: Species: Meas.:

EP9340 2 Date (YY/MM/DD): Area: Station:

Quad. size: Species: Meas.:

Date (YY/MM/DD): Area: Station:

Quad. size: Species: Meas.:

EP9340 2 Date (YY/MM/DD): Area: Station:

Quad. size: Species: Meas.:

EP9340 2 Date (YY/MM/DD): Area: Station:

Quad. size: Species: Meas.:

Area: (1) Nanaimo Dr.
(2) Jump Cr.

Quadrat size: (1) 0.25m²
(2) 0.5m²
(3) 1.0m²
(4) 2.0m²

NANAIMO RIVER WINTER FORAGE ASSESSMENT: (3) BROWSE

EP9340 2 Date (YY/MM/DD): Area: Station:

Species: D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D = diameter at area or below plot;
L = length from diameter measuring point
Twigs = number of twigs above area
Max. L = length of longest twig above area

EP9340 2 Date (YY/MM/DD): Area: Station:

Species: D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

EP9340 2 Date (YY/MM/DD): Area: Station:

Species: D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

EP9340 2 Date (YY/MM/DD): Area: Station:

Species: D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

EP9340 2 Date (YY/MM/DD): Area: Station:

Species: D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

D: L: Twigs: Max. L:

E.P. 923

NANAIMO RIVER HYPOTHESIS TESTING SAMPLE FORM

Date (YY/MM/DD): [1 2 3 4 5 6]

Home range of deer #: [7 8 9 10]

Habitat type: [11 12 13 14 15 16 17 18 19 20 21]

Sample point number: [22 23 24]

Pre- or post- event: [25]

Moosehorn value*: [26 27]

Slope (%): [28 29 30]

Aspect (°): [31 32 33]

Snow depth

Total (cm.): [34 35 36]

Fresh (cm.): [37 38]

Snow age: [39]

Snow condition: [40]

Snow density tube

Outside depth: [41 42]

Inside depth: [43 44]

Core problem: [45]

Empty tube wt.: [46 47]

Total tube wt.: [48 49]

Comments

[50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80]

Date (YY/MM/DD): [1 2 3 4 5 6]

Home range of deer #: [7 8 9 10]

Habitat type: [11 12 13 14 15 16 17 18 19 20 21]

Sample point number: [22 23 24]

Pre- or post- event: [25]

Moosehorn value*: [26 27]

Slope (%): [28 29 30]

Aspect (°): [31 32 33]

Snow depth

Total (cm.): [34 35 36]

Fresh (cm.): [37 38]

Snow age: [39]

Snow condition: [40]

Snow density tube

Outside depth: [41 42]

Inside depth: [43 44]

Core problem: [45]

Empty tube wt.: [46 47]

Total tube wt.: [48 49]

Comments

[50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80]

---

* Moosehorn value: The total number of the 25 dots that are unobstructed by the canopy.

Home range categories: (1) pre-storm (2) post-storm

Snow age categories: (1) fresh (2) old

Snow condition categories: (1) powder (2) sticky (3) slushy (4) granular (5) recrystal (6) crusted

Core problems (when INSIDE depth < OUTSIDE depth): (0) none (1) crushing (2) air pocket (3) compaction (4) shrubs (5) unknown

SNOW INTERCEPTION SAMPLING FORM.
E.P. 934

Date:.....

Empty snow tube wt :.....

Site:.....

SAMPLE #	SNOW DEPTH FRESH	SNOW DEPTH TOTAL	SAMPLE #	SNOW DEPTH FRESH	SNOW DEPTH TOTAL	SAMPLE #	SNOW DEPTH FRESH	SNOW DEPTH TOTAL	SAMPLE #	SNOW TUBE MEASUREMENTS OUTSIDE	INSIDE	TOT. WT.	C*
01			23			45			01				
02			24			46			04				
03			25			47			07				
04			26			48			10				
05			27			49			13				
06			28			50			16				
07			29			51			19				
08			30			52			22				
09			31			53			25				
10			32			54			28				
11			33			55			31				
12			34			56			34				
13			35			57			37				
14			36			58			40				
15			37			59			43				
16			38			60			46				
17			39			61			49				
18			40			62			52				
19			41			63			55				
20			42			64			58				
21			43			65			61				
22			44			66			64				

TIME OF MEASUREMENT: ..... TEMPERATURE (°C): ..... WIND (N,I,E,S): .....

SNOW TYPE (Dri,Powdery): ..... PRECIPITATION (Y,N): ..... PRECIP. TYPE (Rain,Snow): .....

OTHER: .....

* If INSIDE core depth < OR OUTSIDE core depth, include reason: (1) CRUSTING, (2) AIR POCKET, (3) COMPACTION, (4) BRIDGE, (5) BRIDGE

CANOPY CLOSURE SAMPLING FORM.

Site:.....

E.P. #	SITE #	SAMPLING DATE (dd/mm/yy)	SAMPLE #	MOOSEHORN VALUE*	MOOSEHORN %CC*	SAMPLE #	MOOSEHORN VALUE	MOOSEHORN %CC	SAMPLE #	MOOSEHORN VALUE	MOOSEHORN %CC
934		/ /	01			23			45		
.**	.	.	02			24			46		
.	.	.	03			25			47		
.	.	.	04			26			48		
.	.	.	05			27			49		
.	.	.	06			28			50		
.	.	.	07			29			51		
.	.	.	08			30			52		
.	.	.	09			31			53		
.	.	.	10			32			54		
.	.	.	11			33			55		
.	.	.	12			34			56		
.	.	.	13			35			57		
.	.	.	14			36			58		
.	.	.	15			37			59		
.	.	.	16			38			60		
.	.	.	17			39			61		
.	.	.	18			40			62		
.	.	.	19			41			63		
.	.	.	20			42			64		
.	.	.	21			43			65		
.	.	.	22			44			66		

*Moosehorn value is the total number of the 25 dots that are unobstructed by the canopy.
*%CC is the per cent canopy closure. It is calculated as (25 - moosehorn value) x 4.
*Represents repeated/redundant information.

E.P. 934 INTERCEPTION STUDY STAND MENSURATION FORM.

SITE # and DESCRIPTION: ..... SAMPLING DATE: ..... PLOT DIM. (m.): .....x .....

TREE NUMBERS BY DIAMETER CLASS (DBH classes in centimeters)

<1.0: ..... 1.1 - 2.0: ..... 2.1 - 3.0: ..... >3.0: .....

STEM DENSITY

.....stems/ha.

Tree #	Spp.	Total Height	CROWN MEASUREMENTS					DBH	Total Age	HEIGHT CALCULATIONS								% in Crown	BASE CALC.	
			Height	Length	Width	Max.	Min.			Top	Bot	Tot	S.D.	Slope	N.D.	Ht.	Cor		Bl.Ba	Corr.

DECISION KEY FOR SELECTING AREA PRIORITIES AND SCHEDULING ACTIVITIES

This key is intended for use during the early part of the winter when decisions about which type of sampling to conduct are hardest. After 3 samples of each type (snow/tracks, intensive telemetry, hypothesis testing) have been taken, further sampling priorities will have to be decided by reviewing progress, data or the objectives of the projects.

1	Fresh snowfall of at least 7.5 cm at roadside snow stakes beside J3 road below Dunsmuir Creek winter range	2
1'	No snowfall or less than 7.5 cm fresh snow	8
2(1)	Average snow depth 7.5 cm or more in unspaced stand beside J3 road below Dunsmuir Creek winter range	3
2'	Average snow depth less than 7.5 cm in J3 unspaced stand	11
3(2)	Snow and tracks have previously been sampled less than 3 times or there has been no sampling after one of the following - snowfall with wind or a snowstorm without wind	4
3'	Snow and tracks have previously been sampled at least 3 times, including at least once after snow fell during windy conditions and at least once after snow fell during calm conditions	9
4(3)	No snow station and track transect sampling has yet been done	5
4'	Snow stations and track transects have been sampled at least once	6
5(4,7)	Average snow depth 7.5 cm or more in Jump Creek winter range beside J11 road	Sample snow stations and track transects in both watersheds-Jump Creek first day, Dunsmuir Creek second day
5'	Average snow depth less than 7.5 cm in Jump Creek winter range...	Sample snow stations and track transects in Dunsmuir Creek only
6(4')	No intensive radiotelemetry sessions have been conducted	Conduct an intensive radiotelemetry session to determine locations and home ranges of as many deer as possible that were collared since winter 1983-84
6'	At least one intensive radiotelemetry session has been conducted	7
7(6')	No sample of snow stations and track transects has been taken after one of the following - snowfall with wind or snowfall without wind - and the recent snowfall meets the criteria for the sample required, or less than 3 samples of snow stations [illegible]	5
7'	All snow station sampling fulfilled	8
8(1',2',7')	Snowpack less than 7.5 cm in Dunsmuir winter range and deer are unstressed (early winter or late in a mild winter)	No sampling

Cont'd...2

8'	Snowpack greater than 7.5 cm or deer have been stressed by long period(s) of snowpack greater than 12 cm which has now begin to melt	9
9(3',8')	No intensive telemetry session has been conducted, or current date is after 1 February and last intensive telemetry was conducted at least 4 weeks ago	Conduct an intensive telemetry session
9'	Less than 4 weeks since last intensive telemetry session	10
10(9')	Deer have shifted short-term home ranges in response to weather or habitat change, and new home range of at least one animal can be easily defined	Set a hypothesis about 1 or 2 animal's habitat use(s) before and after the change, then sample the "before" and "after" home ranges
10'	Deer have shifted home ranges but new ranges can't be easily defined due to extensive movement, ...	Sample snow and forage on transects through home ranges in areas where one or more deer are located, preferably near or in Jump or Dunsmuir winter ranges
11(2')	Snow and tracks have been previously sampled at least once	8
11'	Snow and tracks have not been sampled	12
12(11')	Average snow depth 7.5 cm or more at snow stakes on Jump Creek Road	Sample snow and tracks but not forage in both watersheds - Jump Creek first, Dunsmuir Creek second - where snow is absent or patchy on a transect segment record track count as missing (put a line through the appropriate box on the data form)
12'	Average snow depth less than 7.5 cm at snow stakes on Jump Creek road	Sample snow and tracks but not forage in Dunsmuir Creek - where snow is absent or patchy on a transect segment, record track count as missing